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DEFENCE RESEARCH AND THE NATIONAL ECONOMY

DR. O. H. WANSBROUGH-JONES, chief scientist in the Ministry of Supply, stated in a lecture to the Royal Society of Arts last year that the relation between the scientist and the Armed Services in Great Britain is satisfactory, and scientific advice is being rendered normally and effectively up to the highest levels. Concern, as expressed in the recent debates on defence in Parliament and elsewhere, is rather with the other aspect of defence research—its cost and the disposition of our available resources between defence research and civilian research. Even when full allowance is made for the great value to British industry and to science, to which Dr. Wansbrough-Jones testified, of much of the scientific research and development carried out on behalf of the Services, the level of that expenditure provokes the question whether it is not already too high.

The "Statement on Defence, 1954"* puts the expenditure of Britain on defence research and development in 1954–55 at nearly £160 million, or, according to the Prime Minister, about double that in 1951–52. No analysis of the distribution of this research effort between the different Services or Ministries is attempted in the analysed defence budget, although the distribution of the total expenditure on production and research is shown. Only general comments are made on the complicated character of new weapons coming into use and the need for developing entirely new techniques before successful laboratory experiments issue in practical weapons for the Armed Services. The time required for the various stages of research, development and production tends to increase, and the weapons themselves are extremely and progressively expensive.

These are the factors which have prompted the suggestion that even now we are spending too little on research and development, and which make so difficult the decision how best to divide available funds between improvements—and possibly major improvements—in current weapons and equipment, and research and development on new weapons. As to the nature of the new developments, the Statement says little. Good progress has been made with the development of a fighter aircraft the speed of which well exceeds that of sound, and a research aircraft of this type is expected to fly within the next twelve months. The new fighters now being introduced into the Royal Air Force will in due course be equipped with powerful air-to-air guided weapons which will perhaps quadruple their fighting power. Good progress is being made in the development of surface-to-air guided weapons, and these developments are being supported by continual improvements in arrangements for detecting incoming enemy aircraft and in the control and reporting system generally. In land warfare, the effects of research and development policy are to improve the efficiency of the ground forces rather than to make it possible to reduce numerical strength. At sea, the introduction of the steam catapult and angled deck has made possible the operation of aircraft of much higher performance from aircraft-carriers. These developments, together with the great improvements in methods of anti-submarine detection and in naval weapons generally, will greatly increase the ability of the Royal Navy to carry out its main function of controlling sea communications.

It is obvious that the Statement on Defence contains far too little information to permit informed public discussion of defence policy and of the soundness of the actual compromises on which the Government has decided. As Lord Alexander of Hillsborough pointed out, the ordinary citizen can form no idea where these defence expenditures will lead us. To some extent this is inevitable; but something could well have been said, within the limits of security, to indicate why there is no mention of the replacement programme by new construction which a year ago the First Lord of the Admiralty said is vital if the Royal Navy is to exist as a balanced and efficient fighting force. Enough was said in the debates in Parliament to show the wisdom of giving the nation the fullest possible reasoned statement, at least where a fundamental change in the traditional role of one of the Fighting Services is contemplated. There should be no secrecy for secrecy's sake.

Quite apart from the concern which has been provoked by the explosion of the hydrogen bomb since the defence debates began, and the probable need for a revision of the priorities laid down in the Statement on Defence, the Government should go to the limit in taking the public into its confidence in this matter of defence development and research. When the Select Committee on Estimates reviewed the national expenditure on research and development in 1947, the Defence Research Policy Committee had only just been constituted. Annual reports from such a Committee are not to be expected; but little, if anything, has since been published to show that the weaknesses relating to defence research and development revealed by the inquiry have been removed. The position in regard to atomic energy had, of course, been transformed before the Atomic Energy Corporation Bill was presented to Parliament; but in insisting that, if it is to discharge its duty, Parliament needs to be provided periodically with 'progress reports' setting out the range, aims and progress of Government research activities, the Select Committee made no exception for defence. The very magnitude of the increase in expenditure on defence research and development is a further reason for implementing its strong recommendation that those estimates should be reviewed independently at more or less regular intervals. At seven years such a review is overdue.

This is not the inquiry for which Lord Alexander of Hillsborough pressed in the debate on the Statement on Defence in the House of Lords on March 16. That was rather for an inquiry into defence policy and its formulation, which, as Lord Swinton rightly observed, is one of the most important functions of the Government and a duty which no Government could

* Statement on Defence, 1954. Pp. 26. (Cmd. 9075.) (London: H.M. Stationery Office, 1954.) 1s.

possibly devolve on anyone else. Even an inquiry which would dispel misgivings apparent in the debate as to the balance of expenditure on man-power and on production, research and development might go too far in that direction.

In any event, substantial support was forthcoming in the House of Lords debate for the view that the balance is about right. Lord Alexander of Tunis, the Minister of Defence, remarked that the next three or four years would see the completion of many of the major projects towards which our research and development programme has been directed for some years; he referred also to the indispensable co-operation of Australia in our weapon research and development, and pointed out that, while in 1950 about one-third of our total defence expenditure went on production, research and development, in 1954, out of a total expenditure nearly twice as great, almost half was on production and defence research. With an expenditure which has thus almost trebled in four years, it is only reasonable that Parliament should have at least such assurance as the Select Committee on Estimates could give that all possible sources of duplication of effort or waste of resources have been eliminated, the weaknesses indicated by the earlier inquiry removed and that no departmental prejudices or conservatism are giving rise in the fresh circumstances to new sources of inefficiency or waste.

The Minister of Defence spoke wisely of the need for making full use of our imagination in dealing with the difficult problems now confronting us without losing sight of present realities and needs, and of the importance of a forward-looking policy in making the best use of the defence resources of Britain in an era of scientific progress. This more limited inquiry, however, could have its part in steadying public opinion and engendering confidence as to the balance of our effort not only in the field of defence but also between our defence effort and that in other fields. This is especially true of research and development, where any serious distortion can well retard progress both in the field of defence and that of industrial and economic development. Moreover, as Lord Hore-Belisha insisted, a defence programme on a purely national basis is anachronistic. He believes that within the Atlantic Treaty Organization there is room for much closer cohesion to prevent overlap in research and the production of weapons.

Since the debates on the Statement on Defence, further information regarding the hydrogen bomb explosions have given point to this criticism. Assurances have been forthcoming from scientists and from the chairman of the United States Atomic Energy Commission that the tests are not beyond control or limitation. It seems clear, too, that they have strengthened President Eisenhower's argument for a greater sharing of knowledge between the United States and Britain and her other partners in the defence of the free world.

While, however, from the point of view of advancing knowledge, the hydrogen bomb and like experiments are necessary and are being carried on with due regard to all reasonable safeguards, both legal and scientific, it may still be asked whether we have not in fact reached, or approximated to, the point of no return. The purpose of continued experiment is to prevent any potential enemy of the free world from gaining a completely decisive lead. It may be argued that atomic weapons have already reached a stage at which it is meaningless to speak of a decisive lead. Here it needs to be remembered again that the limited resources of Britain do not permit us to provide our Armed Forces with all those things which they would wish to have. The Minister of Defence, too, stressed the limitations of our resources and, bearing in mind what Dr. Wansbrough-Jones said about the efficiency of our system, it is most unlikely that any tests have been or will be made beyond those essential to the design of reliable and manageable weapons. The tests are extremely costly and laborious, and those responsible for carrying them out are acutely aware of the pressure for financial economies, which is just as strong in the United States as in Britain.

There is every reason for scientists to do what they can to urge the freer exchange of information on atomic energy and the reduction of the area of secrecy regarding defence research and development to the narrowest limits consistent with security. Responsible public discussion of these questions by them could do something to help steady public opinion, and to make clear that so far as atomic weapons are concerned the only alternative to developing a sufficient supply of effective weapons of this type as deterrents is, not to refuse to have anything to do with them, but to secure an agreed acceptance of effective control. To outlaw the atomic or the hydrogen bomb is meaningless without a system of enforced law, the first condition of which is the clear knowledge of facts which only a constant and vigilant inspection in every country could supply.

Such a system the United States and Great Britain and other members of the United Nations, except only the U.S.S.R. and its satellite States, have consistently been prepared to accept. President Eisenhower has since made his offer for the pooling of supplies of uranium, thorium and other materials in the hope of providing a new means to agreement and understanding, and possibly later to full international control of atomic energy. Until, however, the abatement of suspicion permits the adoption of an agreed system of prohibition in which both sides have full confidence, it would be folly not to strive to ensure that at least equal striking power remains in the hands of the less secretive and less aggressive side. The Statement on Defence and debates in Britain show clearly how large is the responsibility of statesmen for securing the political conditions in which, if not disarmament, at least the sharing of information, research and production could lighten the burden of defence on individual nations. It is no less clear how much depends also on the scientist, in order that the resources made available for defence may be used most efficiently and to the greatest advantage, not merely of the Armed Forces but also of the national economy as a whole.

CIRCULATION IN THE NORTH ATLANTIC OCEAN

By HENRY STOMMEL
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SIXTEEN years ago there appeared in *Nature*[1] an announcement of plans for a five-year co-operative programme for the study of the circulation in the North Atlantic Ocean.

The first part of this programme, to be performed by the *Atlantis*, research vessel of the Woods Hole Oceanographic Institution, was to make periodical hydrographic traverses across the Gulf Stream from Montauk Point on the North American coast to Bermuda. From measurements of temperature and salinity, made in a vertical section of the ocean, it is possible to construct the field of density; by virtue of the laws of hydrostatics, the pressure field may then be computed. As in the atmosphere, large-scale horizontal pressure gradients in the ocean are largely balanced by Coriolis forces associated with components of the velocity field normal to them. Oceanographers make frequent use of this so-called 'geostrophic approximation' to calculate the velocity field from the density field because of the great difficulty of making direct current measurements in the sea. It was hoped that frequent hydrographic sections would reveal seasonal fluctuations in the transport of the Gulf Stream system—all of which passes between the North American mainland and Bermuda.

The second part of this programme was to be carried on from the Bermuda Biological Station, using a small vessel provided by a grant of the Royal Society. Because of the peculiar location of the Island of Bermuda, at the centre of the North Atlantic circulation, it was hoped that frequent measurements of the vertical density structure near the Island could be correlated with the transport fluctuations of the Gulf Stream. Should this prove to be the case, such simple local measurements might eventually be of the very greatest importance for European meteorology and for fisheries hydrography. In any event, it was felt that this phenomenon ought to be explored. It was also proposed that this small vessel, based at Bermuda, should undertake a programme of measurement of wind-drift currents, in order to check the Ekman wind-drift current theory.

Within a year these plans were hopelessly disrupted by the Second World War. However, Iselin[2] was able to publish in 1940 a preliminary study of thirteen *Atlantis* sections made up to that time. Of course, the number of these sections is very small for the purpose of analysis for periods. Moreover, there are gaps in the series: two sections are available for 1937; five during May–October 1938; and six during May 1939–January 1940. With the latter exception, there are no winter-time observations, a fact which was inevitable because of the relatively small size of the *Atlantis*. Iselin showed what may be interpreted as a seasonal variation in the transport of the Gulf Stream, the most pronounced feature of which is a distinct minimum during October–November. This seasonal variation was supported by tide gauge observations obtained at Charleston and Miami (it is to be expected that changes in the field of density in the ocean will be accompanied by changes in the mean elevation of the sea surface); therefore, it seemed likely that the transport of the Gulf Stream varies seasonally from a minimum transport of at most 76 million, to a maximum of at least 93 million, cubic metres per second.

During the war years, no study of the Gulf Stream system was made. However, an instrument of great practical importance, the bathythermograph, was

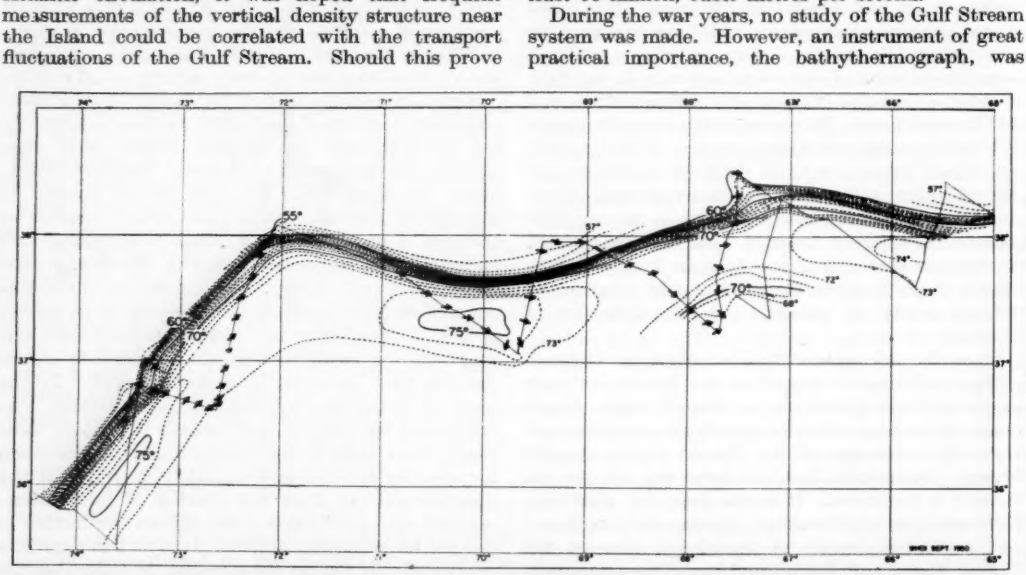

Fig. 1. Fuglister and Worthington's chart of the mean temperature (°F.) in the upper 200 metres of the Gulf Stream on June 8, 1950, showing the meander-pattern. The solid zig-zag line is the ship's track. The small arrows show the direction of flow (but not speed) as indicated by towed electrodes. The very large horizontal gradient of temperature shown by the crowding of isotherms is along the left side of the Stream. The main body of the Gulf Stream is limited to a band extending not more than 1° of latitude to the south of these intense thermal gradients. In the course of two weeks this meander-pattern was observed to progress about one-half wave-length to the east

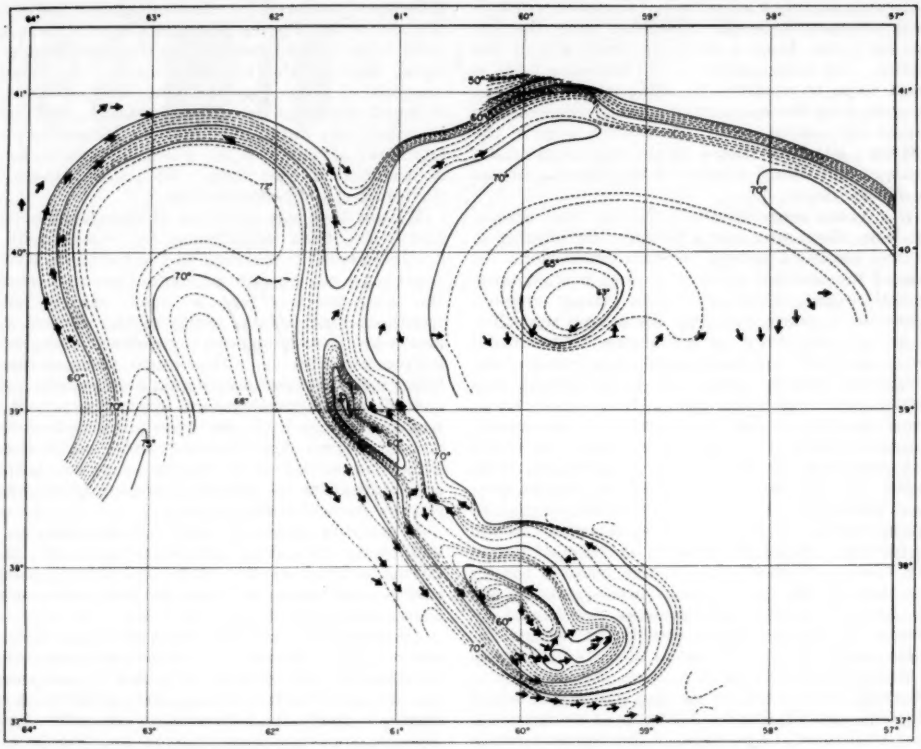

Fig. 2. Mean temperature (°F.) of the upper 200 m. layer on June 17, 1950. Current arrows from the 'G.E.K.'. Continuation to the east of the meanders shown in Fig. 1. It portrays one stage in the development of the unstable breaking up of a meander-pattern in which a large mass of cold northern water is becoming isolated in the warmer surface waters to the south of the Gulf Stream

devised for the rapid measurement of temperature as a function of depth (900 ft. is the practical maximum depth, at present) from a ship under way. In the North Atlantic Ocean, 210,000 bathythermograph soundings have now accumulated. This useful instrument has also revealed extraordinary horizontal eddy and meander formations along the Gulf Stream, complications which were not previously expected, and which throw some doubt on the validity of the 'geostrophic approximation' for transport calculations because of the small radius of curvature exhibited by some of these features. It therefore seemed possible that the Gulf Stream traverses made by Iselin might have been through meanders, and that the resulting errors in computed transports could have been as large as the variations he attributed to seasonal influences. More recent evidence (referred to later), however, supports Iselin's original interpretation despite the uncertainty of the location of the *Atlantis* traverses relative to meanders. Although it would be very desirable to evaluate directly the various terms in the dynamical equations for even a single meander, by measuring density and velocity over a small network of stations at intervals of a day for a period of several weeks, such a programme is quite beyond the resources of oceanographical science at present.

The exploration of meander-patterns reached a high point in the multiple-ship survey of 1950[3], during which seven vessels of the U.S. and Canadian Navies, as well as research institutions, were engaged for more than two weeks in producing a synoptic chart of a segment of the Gulf Stream eight hundred miles long. The chief result of this effort was to show the existence of a series of horizontal wave patterns beginning at Cape Hatteras and extending downstream to long. 65° W., with a wave-length of approximately 200 km., and a downstream phase-velocity of 11 miles a day (the water in the centre of the Stream moves with a particle velocity of 100 miles a day). At long. 61° W., a meander-wave of excessive amplitude was observed as it developed into a detached eddy of cold water in the warmer water on the offshore side of the Stream. The growth of this single large eddy is interesting because it is the only direct observational evidence of large-scale lateral mixing processes so often postulated in theoretical studies of the dynamics of oceanic circulation.

The introduction of towed electrodes[4] has proved very useful in such synoptic surveys; although a way for deducing the total transport of the Stream from towed electrode measurements is known on theoretical grounds, it has not yet proved possible to do so for practical reasons. The great practical advantage of towed electrodes is that they provide an instantaneous estimate of surface current from a ship under way; thus the oceanographer knows at every moment which way to direct his vessel to stay with the Stream or to cross it.

Another instrument, the airborne radiation thermometer, has made possible the rapid aerial mapping of meander-patterns by means of their surface temperature. Used from a low-flying aeroplane, this

instrument consists of an infra-red detector which is exposed alternately to the radiation from the sea surface and that from a reference body within the aeroplane. The temperature of the reference body is adjusted so as to produce the same signal upon the detector as does the sea surface; their temperatures thereupon are nearly equal. The inshore edge of the Gulf Stream has been traced all the way from Miami to south of the Grand Banks by this means, in the space of two days.

In the years immediately following the Second World War, there was also a reawakened interest in theoretical study of general oceanic circulation. In a study of the detailed weak horizontal flow patterns in central oceanic areas (excluding strong currents like the Gulf Stream), Sverdrup discovered that they could be accounted for as a balance between the tendency for water moving along meridians to take on a relative vorticity about the local vertical, and the curl of the local wind stress. In another study, Stommel discovered that the east–west asymmetry of oceanic circulations could be explained in terms of the variation of the Coriolis parameter with latitude. In 1950 Munk[5] published an elegant synthesis of these studies in which he was able to deduce the main features of the horizontal transport in the ocean from the actual distribution of the wind stress. Briefly stated in qualitative terms, Munk's theory asserts that the stationary mean-vorticity field of the North Atlantic surface circulation is maintained by a balance of three processes tending to change the vorticity at any point: (1) the local curl of the mean wind stress, (2) the change of relative vorticity due to north–south components of motion (variable Coriolis parameter), and (3) lateral diffusion of vorticity by macro-turbulence. Over most of the North Atlantic the curl of the mean wind stress has the same sign, and since horizontal velocity gradients are too small to make process (3) important, process (2) must provide the necessary balance, and the meridional component of transport hence of same sign (southward). Conservation of mass requires provision for this water to be returned northward; the mathematical solution of the vorticity equation provides such a northward flow in an intense narrow high-velocity 'boundary layer' along the western coast of the ocean where processes (2) and (3) completely dominate process (1). This theoretical concept of a western 'boundary layer' corresponds to the Gulf Stream system. Comparison of the amounts of water transported by such a theoretical Gulf Stream with those measured is encouraging. The chief difficulty in reconciling this theory with the actual Gulf Stream is to discover lateral mixing processes in the Stream sufficient to transfer the vorticity required. Except in the large eddies at long. 61° W., the water in the Stream seems remarkably immiscible with its environment.

Tide gauge observations have gradually been accumulated from gauges recently established at Cat Cay, Havana, and Bermuda, a basic source of information which was largely unavailable from these places before the War. In addition, we have new techniques for measuring quantities indicating the strength of the North Atlantic circulation: since August 1952, measurements of electrical potential difference across the Florida Straits have been regularly made on a submarine cable between Key West and Havana. When the tidal components and the short-period variations due to magnetic storms have been eliminated, there remains a potential difference produced by electromagnetic induction of the sea water moving through the earth's magnetic field, which is proportional to the total transport of water through the Florida Straits. A preliminary analysis of these measurements has confirmed the seasonal variation described by Iselin, and has also revealed very rapid short-period fluctuations in the transport of water of the Florida current—as much as twofold in ten days. At present these latter fluctuations defy explanation.

Within the past year, an Oceanographic Observatory has been established by the Woods Hole Oceanographic Institution at the Bermuda Biological Station for the purpose of making synoptic studies of the north-western Sargasso Sea. Hourly measurements of wind-drift currents in the shallow surface layers are now being made regularly, using wireless telemetering buoys. Resistance thermometers are being installed permanently on a submarine cable to a depth of 1,500 fathoms, in order that a continuous long-term record of the thermal structure in this critical portion of the North Atlantic can be obtained. This Observatory is the first attempt on the part of oceanographers to obtain continuous day-by-day records from the deep ocean.

It may be expected that in the years to come long-term measuring programmes, such as this Bermuda thermometric cable, will play an increasing part in oceanography. They are certainly much more economical than ships.

In conclusion, it should be evident that despite the fact that the complexity of the ocean circulation is considerably greater than supposed sixteen years ago, the number of techniques of observation has increased correspondingly, and there is no reason to despair of achieving an understanding of the North Atlantic circulation.

[1] Iselin, C. O'D., *Nature*, **141**, 772 (1938).
[2] Iselin, C. O'D., Pap. Phys. Oceanogr. Meteor. (Cambridge and Woods Hole, Mass.), **8**, No. 1, 1 (1940).
[3] Fuglister, F. C., and Worthington, L. V., *Tellus*, **3**, No. 1, 1 (1951).
[4] von Arx, W. S., Pap. Phys. Oceanogr. Meteor. (Cambridge and Woods Hole, Mass.), **11**, No. 3, 1 (1950).
[5] Munk, W. H., *J. Meteor.*, **7**, No. 2, 79 (1950).

STRUCTURE OF OPTICALLY ACTIVE COMPOUNDS IN THE SOLID STATE*

By Prof. J. M. Bijvoet
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In the great successes of X-ray analysis that determined structures as complicated as those of sterols and alkaloids and that now ambitiously approach the domain of Nature's most complicated biochemical compounds, the proteins, the central problem of X-ray analysis, namely, the location of the atoms in the crystal, was solved by Fourier methods.

As early as 1915, Sir William Bragg introduced the underlying conception of the crystal[1]. Instead of the atomic positions, the electron density all over the crystal is considered, in which distribution the atoms finally reveal themselves. This periodic electron distribution may be developed in a Fourier series, that is, it may be seen as a homogeneous background that is modulated by the superposition of density

* Substance of a course of three lectures delivered in the University of London on March 15, 17 and 19.

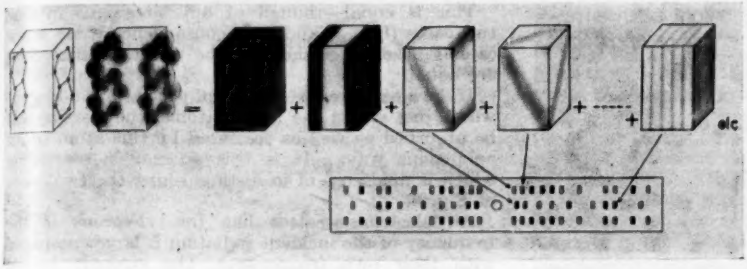


Fig. 1. Relation between density waves and X-ray diagram

waves. As these waves must satisfy the periodicity of the crystal, the Fourier development is restricted to a discrete series.

Each density wave causes a reflexion spot on the X-ray diagram, which consequently gives us information about the wave (see Fig. 1). This close relation between X-ray diagram and density waves makes this conception of the crystal eminently useful in X-ray analysis. The position of the diffraction spot gives us the orientation and period of the density wave; its intensity gives the amplitude. The *phase* of a density wave—that is, the distance of its maximum from the origin of the cell—is lost in the X-ray diagram, however, direction as well as intensity of the reflexion being insensitive to a parallel shift of the reflecting wave front. This lack of information about the phase prohibits the direct synthesis of the Fourier waves, which otherwise would immediately reveal the atomic arrangement from the X-ray diagram. The determination of the phases of the density waves thus constitutes the central problem in the Fourier method of X-ray analysis.

The crystal can be described in either of two ways: by the position of the atoms, or by its Fourier waves. Nature gives us part of either description: the atoms that are present, but not their co-ordinates; she gives the density waves, but not their phases. The problem is to translate either of these complementary sets of data into the language of the other description, thus attaining a description which is complete.

The method that starts on the basis of Fourier waves owes its prevalence to the fact that in Fourier synthesis general methods could be devised for determining phases systematically.

We propose to consider here the heavy-atom technique of phase determination in the form of the isomorphous substitution method. In this method two isomorphous crystals are used. These derivatives have exactly the same crystal structure except for the substitution of one of the atoms by a heavier atom of approximately the same size. From the resulting changes in intensity the unknown phases can be derived. In particular, I propose to extend the common scheme of this method to the *non*-centrosymmetrical case. Obviously in this case the location of the density waves is more difficult than when a centre is present, since a centre, by reason of symmetry, from the very onset restricts the possible locations to the extreme cases of maximum or minimum in the origin (centre).

The complete determination of the phases in the non-centrosymmetrical case implies the solution of the old problem of the determination of the absolute configuration of optically active compounds, a problem which chemistry studying the *mutual* behaviour of compounds cannot solve.

Let us outline the procedure of the isomorphous substitution method in this general case. Though the structure of the crystal is not known, the configuration of the heavy atom, which strongly influences the intensities, can easily be determined by a special procedure, the Patterson synthesis, and we shall consider it here as known. By the isomorphous substitution an extra electron density corresponding to the latter configuration is introduced. We shall call this known density the 'test density', because it will be used to test the location of the compound waves. Added to the light compound, it yields the density of the heavy compound (see Fig. 2, left-hand column). If we represent each of these three electron densities by its Fourier waves, the sum relation will also hold for every set of the component Fourier waves (Fig. 2). It is this additivity relation which permits the determination of the phase angles—though only in absolute value. For in each set the test wave is known in amplitude and phase, whereas the amplitudes alone of the other two terms are known from the X-ray diagrams. In the addition process, only the correct phase of the light-compound wave will yield the observed amplitude of the heavy-compound wave. The unknown phases can thus be calculated from the three known amplitudes.

It is interesting to note that this problem of catching phase differences by turning them into amplitude differences is by no means restricted to X-ray analysis. It also turns up in, for example, microscopy. When the object is perfectly trans-

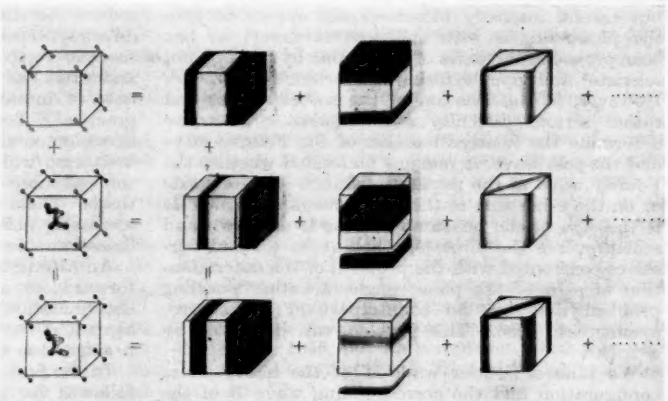


Fig. 2. Additivity relation between electron densities of light- and heavy-atom compounds and their Fourier waves respectively

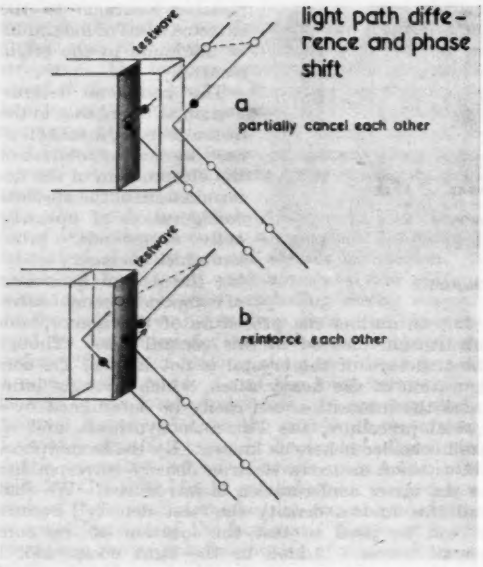


Fig. 3. Determination of phase sign by anomalous scattering

parent, there are only phase differences in the image, which consequently cannot be seen. In intercepting the undeviated light, a constant vector is subtracted in every point of the image, and vectors of different amplitude result.

The amplitude or intensity comparison of light and heavy compound upon which phase determination is based is widely used in the centrosymmetrical case. Since the famous example of phthalocyanine[3], a number of centrosymmetrical projections of complicated compounds have been determined along these lines. It is fortunate for the easy applicability of the method that most biochemical substances crystallize in space groups with a two-fold axis, so that we have at least one centrosymmetrical projection. For the non-centrosymmetrical projections the determination of the phase angle obviously needs more accurate intensity data, but careful intensity measurements appear to give the phase angles with sufficient accuracy, as has been proved in the cases of strychnine hydrosulphate/selenate[3] and glycyltyrosine hydrochloride/bromide[4]. However, in the location of the waves, a last and rather serious difficulty still remains. When we determine the relative location of the Fourier wave and the test wave, it remains undecided whether the Fourier wave at the required distance is on one side or on the other side of the test wave (see Fig. 3). It is the *sign* of the phase angle that is unknown and still prevents the direct synthesis. So we find ourselves confronted with the problem of the determination of sign of the phase angle, a rather puzzling problem that has no counterpart in the centrosymmetrical case. This problem can be solved by a trick[5].

We take a Fourier wave A of the heavy atom configuration and the corresponding wave B of the rest of the crystal. For ordinary X-rays it is the path difference only between A and B which causes the phase differences between their diffracted beams, and $\varphi_B - \varphi_A = \varphi_B - (\varphi_A)_{\text{path}}$.

This is equal—though of opposite sign—in our two cases (Fig. 3) and as a consequence these cases cannot be distinguished, as the resulting intensities are equal.

If, however, we use X-rays of special wave-length, which just excite the heavy atoms, the X-rays will be absorbed as well as scattered by this atom in an anomalous way. It is this anomalous scattering which is made use of in distinguishing the two cases of Fig. 3.

All electrons scatter like free electrons if the frequency of the incident radiation is large compared with their own frequency. The strongly bound K-electrons of the heavy atoms, on the other hand, oscillate and scatter with phase opposite to that of the free electrons. Going from hard to soft X-rays, the K-electrons change their behaviour in the region where the frequency of the incident radiation approaches the proper frequencies of these K-electrons: the phase changes gradually when approaching the absorption limit.

Under these conditions:

$$\varphi_B - \varphi_A = (\varphi_B - \varphi_A)_{\text{path}} + (\varphi_B - \varphi_A)_{\text{primary scattering}},$$

in which only the first term on the right-hand side changes sign for the two situations of Fig. 3. The total difference is seen to take different values, which enables us to distinguish the two situations. The influence of anomalous scattering on the reflexion intensity of a density wave thus makes the determination of the sign of its phase angle possible.

In our microscope example, the different phases in the image were turned into different amplitudes by the interception of the undeviated light. However, phases which are mutually opposite in respect to the intercepted component in this optical case also remain indistinguishable. In the phase-contrast microscope[6], this is remedied by imparting to this component an abnormal phase change instead of intercepting it.

Thus the phase problem in X-ray analysis, that is, the determination of phase angles also in sign, is solved. Theoretically, Fourier synthesis is then straightforward also in the non-centrosymmetrical case, and this synthesis gives the antipode in its absolute configuration since the inversed image has opposite phase-angle signs.

The chart opposite summarizes the whole procedure for different cases of complexity. In the direct synthesis of non-centrosymmetrical structures, there is a gap between what is theoretically possible and what has actually been achieved hitherto. The note of interrogation indicating this gap refers to practical difficulties. It has not yet been thoroughly investigated whether the small effect of the anomalous scattering will be measurable for a sufficient part of the reflexions involved in a complete Fourier synthesis. There is every appearance, however, that the increasing accuracy of the measuring technique will indeed enable us to realize this programme.

An alternative method, which lacks the straightforwardness of the direct method, consists of the determination of the combination of relative phase signs and the subsequent absolute determination of a single one of them.

In the first part of this procedure, which has been followed for strychnine hydrosulphate/selenate and glycyltyrosine hydrochloride/bromide, a Fourier synthesis is made with the double number of waves, both signs of the phase angle being used simultaneously. This double Fourier will give the super-

PHASE DETERMINATION IN THE ISOMORPHOUS SUBSTITUTION METHOD

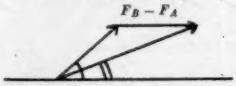
Centre of Symmetry
(determination of amplitude sign)

Heavy atom on centre — Algebraic amplitude addition (1936)

Heavy atom out of centre
(*a*) Location of the heavy atom (Patterson analysis)
(*b*) Algebraic amplitude addition (1939)

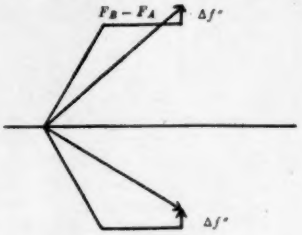
No centre of symmetry
(determination of phase angle)

(*a*) Location of the heavy atom.
(*b*) Determination of absolute value of phase angle from amplitude addition in vector diagram (1949).



(*c*) Synthesis of double Fourier and resolution by geometrical considerations.
(*d*) Phase shift by anomalous scattering (1930).
Determination of absolute configuration (1951).

(*c'*) Determination of all phase signs by anomalous scattering (19 ?).



position of the two antipodes, as the right set of signs results in the actual structure of the opposite set in the inverted structure. These two structures must be separated by geometrical considerations, which require the interatomic distances to be of normal value. These spatial considerations deprive the method of much of its simplicity and beauty; the atoms no longer 'emerge' quite spontaneously from the X-ray data which is so striking in direct Fourier synthesis. It is therefore obvious that along these lines no discrimination is reached between the two disentangled structures. The double Fourier was used for the first time under somewhat different conditions in the structure determination of cholesterine hydriodide[7], and later on, in the form just described, in the cases of strychnine sulphate/selenate and glyceltyrosine hydrochloride/bromide.

The second part of the procedure consists of the decision between the two models after the structure has been found, except for possible inversion. This determination of absolute configuration has been carried out for a compound basic[8] in stereochemistry: for tartaric acid, in the form of the sodium rubidium doub le salt[9] and the acid rubidium salt[10].

Anomalous scattering of the rubidium atoms was obtained by the use of zirconium rays. Although the phase sign of one density wave would have been sufficient, the effect was observed for several reflexions. The phase signs of the salts of dextrorotatory tartaric acid fitted the conventional model, which consequently was proved to correspond to its real configuration.

As early as 1930, Coster proved the 111 and $\bar{1}\bar{1}\bar{1}$ reflexions of zinc sulphide are of unequal intensities for rays exciting the zinc atom. This determination of the sense of a sequence is exactly the problem we met with in the location of our reference wave and the Fourier wave of our crystal. In both cases it is the sense of a polar sequence which must be determined, and indeed can be determined by anomalous diffraction.

The method for determining absolute configuration supplies organic chemistry with a means of establishing the configurational relation between compounds which cannot be converted into each other, or in the conversion of which a Walden inversion may take place that changes the configuration into its mirror image. Investigations in this field are in progress in several laboratories.

It is surprising that, although the structure effect in zinc sulphide was known, the determination of absolute configuration was still thought for many years to be impossible.

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THE QUEEN'S UNIVERSITY, BELFAST

NEW GEOLOGY BUILDING

WHEN Queen's College, Belfast, was founded in 1847, Frederick McCoy was appointed to the chair of geology and mineralogy. In 1854 McCoy left Belfast for Australia, where he continued to build up his world reputation as a palæontologist and was eventually knighted. Wyville-Thompson, who succeeded him, became professor of natural history in 1860 on the amalgamation of his own Department with the Departments of Zoology and Botany. After Wyville-Thompson went to Edinburgh in 1870 and until 1909, geology continued to be taught in the combined Department. With the foundation of The Queen's University in 1909, chairs of zoology and botany and a lectureship in geology were created, Dr. A. R. Dwerryhouse being elected to the new lectureship. On his resignation in 1921, the chair of geology was re-established, and Dr. J. K. Charlesworth was appointed.

In the days of Queen's College, geology shared a common museum and lecture room. Since 1921 the Department has occupied a succession of wooden buildings, at first two army huts, later the orthopædic and later still some of the general wards of the Ulster Volunteer Force Hospital erected in the grounds of the University in 1915. Plans were prepared in the 1930's for a new geology building, with Mr. John McGeagh as architect and Mr. (now Sir) Edward Maufe, R.A., as consultant. The outbreak of war in 1939 and the subsequent shortage of materials postponed the erection of the building until September 1950 and its completion until this year. The formal opening by Sir Edward Bailey took place on April 30.

The geology building forms the south-west wing of a group of buildings to be arranged around a large quadrangle opening to the south on to Elmwood Avenue. Hence the entrance to the geology building

Belfast News-Letter

The Queen's University, Belfast. New geology building

is on the north at one end of a future cloister. The exterior has been designed on clean contemporary lines and has regard for the adjacent agricultural building of Georgian style and for the traditional styles of the University district. The chief materials are Buckley Junction hand-made sand-faced bricks, Clipsham stone and green Borrowdale slates.

The building, rectangular in plan, is about 124 ft. long and 41–44 ft. wide. It has three floors, an attic, and a basement or lower ground floor. The latter, which is excavated beneath the whole site except the lecture theatre, is occupied by women's and men's cloak rooms and lavatories; by a boiler house with solid fuel fed by automatic stoking thermally controlled, and designed ultimately to heat half the buildings around the new quadrangle; by an unpacking room which receives large consignments of rocks or apparatus by a ramp from the gate leading to the agricultural court; and by a rock-cutting room the ceiling of which is cork-insulated to eliminate vibration and sound from the rest of the building. A full-sized lift carries the loads to each floor, including the attic.

On the ground floor are the entrance vestibule, senior laboratory, attendant's room, demonstration lobby, lecture theatre and professor's rooms; on the first floor the elementary laboratory, map room and library, and photographic rooms; and on the second floor the large petrology and palæontology laboratories, chemical laboratory and small lecture room. Staff and research rooms occur on each floor. The undivided attic, which extends beneath a mansard roof over one-third of the building, is well lit by circular dome lights of glass in the flat part of the roof and is ventilated by clerestory windows. It provides the research and store space of the future.

The lecture theatre, which seats 160, has mechanical ventilation, electrically operated blinds, dimming roof lights, and a large lecture bench. Uninterrupted views are obtained of the bench, blackboards, coloured geological models, maps and projection screen. The demonstration lobby, on the line of approach to the lecture theatre, serves for the display of photographs, maps and specimens to illustrate lectures and at the same time gives added spaciousness to the entrance hall. The two supporting rectangular columns have been used for depicting the geological column in its chronological, palæontological, petrological and tectonic aspects.

The corridors, which are 8 ft. wide to provide viewing space for the numerous coloured maps, have been reduced to a minimum by placing the lecture theatre, large laboratories and library and map room at the ends of the building. The laboratories are lined along their outside walls with show-cases which fit flush under the windows and rest on drawers. In this way, a separate museum is avoided, all the material in the Department forms part of the teaching collections, and space is provided for new accessions which are immediately available for study: store-rooms as such become unnecessary. The wall cases have dictated the method of heating throughout the building, which is by low-pressure hot-water panels embedded in the ceilings. J. K. Charlesworth

OBITUARY

Dr. E. M. Crowther

AGRICULTURAL science and particularly soil science have suffered a grievous loss in the sudden death of Edward Mortimer Crowther on March 17 at the comparatively early age of fifty-six.

Born near York on April 15, 1897, he was educated at Archbishop Holgate's School, York, and the University of Leeds, where he read chemistry, specializing in agricultural chemistry in his last year. In 1917 he joined the staff of Rothamsted Experimental Station, and ten years later, when he was only thirty, Sir John Russell, who was then director, recognizing his outstanding ability, made him head of the Chemistry Department, a position he occupied until his death. In 1950 he became one of the two deputy directors of the Station.

Crowther's early work was chiefly on the physics and physical chemistry of soils, and he published a series of important papers on methods of mechanical analysis and on soil reaction. His main interest, however, throughout a very active career, was soil fertility and crop nutrition. While maintaining the great tradition of Lawes and Gilbert, he added to their thoroughness the exactitude of modern methods of field experimentation. Recognizing at once the value of the statistical work of R. A. Fisher and F. Yates on experimental design, he became the pioneer of its application to field experiments in agriculture and forestry, and his influence was felt and his advice sought in many parts of the world.

He became one of the greatest authorities on the use of fertilizers, and as a result of his work, major improvements were made in the manuring of various crops, notably sugar beet, potatoes and flax. He demonstrated conclusively, for example, the manurial value of salt for sugar beet, a matter of importance particularly during the war-time scarcity of potash. His work also threw fresh light on methods of soil analysis, and he used field experiments for improving and calibrating these methods. For many years he had been giving attention to the problems of phosphatic fertilizers, including the immobilization of water-soluble phosphate in soil, and latterly he had been employing radiotracer techniques. This work was a good illustration of his method of using the results of field experiments for developing new lines of work in the laboratory, which in their turn reacted on his field approach. During the Second World War, in collaboration with the Building Research Station, he was actively engaged in the development of a silicophosphate fertilizer, and more recently he had been engaged in assessing the value of this and other new phosphatic fertilizers which are being developed to economize in the use of sulphuric acid. His interest in fertilizers, however, did not cause him to neglect organic manures, and he did much work on farmyard manure, sewage sludge, composts and green manuring, endeavouring to assess their manurial value and long-term effects.

During the War he was deeply involved in questions of fertilizer policy. There were difficult decisions to be taken regarding the use of shipping for the importation of fertilizers or food, and the problems of using the limited quantities of fertilizers in those parts of Great Britain which needed them most. With F. Yates he made a survey and critical analysis of all fertilizer experiments in Great Britain and other northern European countries, and the successful rationing policy was largely the application of his work and of his unrivalled knowledge of crop nutrition. He rightly advocated the use of much greater amounts of nitrogen, and the rapid increase in food production was in no small measure due to this. The Ministry of Agriculture frequently sought his advice and made use of his services on many of its committees.

In recent years Crowther became keenly interested in the manuring of forest nurseries and in the rehabilitation by means of 'partial sterilization' of some of the old nurseries which had ceased to raise useful conifer seedlings. He showed that, in general, properly balanced fertilizers are as effective as composts for this purpose, and revolutionized the manuring practice in the Forestry Commission's nurseries.

Crowther's interests were by no means confined to British agriculture. He travelled widely, visiting many parts of Europe, America, Africa, India and Malaya, and those of us who accompanied him on some of these journeys will always recall his tireless energy, his penetrating observation, and his breadth of outlook. It was natural that his early interest in soil classification and particularly in the relation between soil and climate should be intensified by these travels.

Most of his work in the tropics, however, was connected with soil fertility problems, and he planned and supervised many manurial experiments on cotton, oil palm and rubber. He had a special interest in the Sudan, where he collaborated with his brother, the late Dr. Frank Crowther, and he served for many years on the Sudan Government London Advisory Committee and on the Research Advisory Committee of the Empire Cotton Growing Corporation. The Colonial Office made much use of his wide knowledge, and he was a valued member of the Committeé for Colonial Agricultural and Animal Health and Forestry Research.

His capacity for blending academic research with the investigation of practical problems is well illustrated in his publications, the wide range of subjects of which indicate the variety of his interests. He was one of the editors of the *Journal of Agricultural Science* and the *Empire Journal of Experimental Agriculture*, and was active in many scientific societies, including the International Society of Soil Science. In 1951 he was president of Section M (Agriculture) of the British Association, and in 1952 and 1953 of the British Society of Soil Science and the Fertilizer Society. Both as a writer and speaker he was lucid and effective, and he completed the Jubilee Memorial Lectures of the Society of Chemical Industry only a few days before he died.

Among the qualities associated with Crowther in the memory of those who were privileged to know him, his sincerity, integrity and kindliness stand out. The most loyal of colleagues, he would take great trouble to advise and assist the serious worker, however junior; but he had a keen critical faculty and was not slow to expose what was superficial and slipshod. In him, world agronomy has lost one of its foremost workers, and the deep personal affection and professional esteem in which he was widely held have been strikingly shown by the messages received since his death.

He married Miss Elizabeth Dorothy Kay in 1924, and she and their son survive him.

W. G. OGG

NEWS and VIEWS

Agricultural Botany at Reading: Prof. W. B. Brierley

Prof. William B. Brierley, who retires from the chair of agricultural botany in the University of Reading in September, was educated at the University of Manchester and in 1912 was appointed to the staff of the Department of Botany there. In 1915 he went to Kew as joint head of the newly established Pathological Laboratory, and in 1918 to Rothamsted as the first head of the Department of Plant Pathology which, during his period, developed from a small, bare room into a notable centre of plant disease research. In 1932 he succeeded Prof. John Percival at Reading. His personal investigations have been in the fields of phytopathology and microbiology, where his interests and guiding influence have made themselves felt throughout the world: his paper on an albino *Botrytis* in the *Transactions of the Royal Society* is a classic. In Reading he has built up an honours school in the sciences that together constitute the field of agricultural botany, which has sent research workers and teachers to all parts of the world. For a quarter of a century Brierley was honorary editor of the *Annals of Applied Biology*, a task which he carried out with unremitting care and scientific integrity. He is an honorary member of the Association of Applied Biologists and a freeman of the American Phytopathological Society. A welcome visitor to European and American centres of botanical research, and a prolific correspondent, his contacts in many lands have given him a world-wide reputation in the field of applied botany.

Prof. D. W. Goodall

Dr. David W. Goodall, reader in botany in the University College of the Gold Coast, who succeeds Prof. Brierley, graduated at the Imperial College of Science and Technology, London, and worked for some years under Prof. F. G. Gregory on problems of plant development and nutrition. In collaboration with Prof. Gregory he published a valuable book on the chemical composition of plants as an index of their nutritional status. For two years he was in the Colonial Agricultural Service, seconded to the West African Cacao Research Institute, where he worked on physiological problems in the cacao plant. In 1948 he was appointed senior lecturer in botany in the University of Melbourne, where he became especially interested in statistical ecology, and he has developed this interest further in relation to the classification of types of tropical vegetation since his return to the Gold Coast.

National Research Council of Canada: Mr. B. G. Ballard, O.B.E.

Mr. B. G. Ballard, director of the Division of Radio and Electrical Engineering of the National Research Council of Canada, has been appointed to the additional post of vice-president (scientific), in succession to Dr. E. W. R. Steacie, the present president of the Council (see *Nature*, **169**, 1049; 1952). Mr. Ballard graduated in 1924 from Queen's University, Kingston, Ontario, and afterwards was on the Westinghouse staff for five years working on the development of railway electrification. He was appointed to the Division of Physics of the National Research Council in 1930, and during the following ten years he gradually built up the Electrical Engineering Section. This work became extremely important during the Second World War, when Mr. Ballard's efforts included the development of mine-sweepers and other means of protecting ships against enemy magnetic mines. The equipment was used on both coasts as well as on the high seas, and his work was recognized by the award of the O.B.E. In 1946 the Electrical Engineering Section was amalgamated with the Radio Branch of the Division of Physics and Electrical Engineering, and Mr. Ballard was made assistant director of the Division. With the subsequent expansion of work a separate Division of Radio and Electrical Engineering was established in 1948, and Mr. Ballard was appointed its director. In 1949 he was awarded the Ross Medal of the Engineering Institute of Canada for a publication called "Recent Canadian Radar".

Sir Jack Drummond Memorial Fund

Though the raising of funds for a fellowship in memory of the late Sir Jack Drummond has not yet been terminated, sufficient money has already been accumulated for an award to be made available as from October 1. The fellowship will be worth £900 a year, tenable in the first instance for one year, and will be for research on nutrition, with special emphasis on human nutrition, to be conducted in, or in association with, a university department or research institute of similar standing. The award may be made to a comparatively young scientific worker provided he has reached a stage at which he can undertake independent work. Further information can be obtained from Dr. B. Ifor Evans, Provost of University College, Gower Street, London, W.C.1.

New Building for the Radio Research Station

On May 10, Dr. R. L. Smith-Rose, director of radio research in the Department of Scientific and Industrial Research, cut the first sod on the site of a new building being erected at the Radio Research Station, Ditton Park, Slough. This occasion marks another step in the Department's post-war plan for a considerable extension in the programme of research conducted under the advice of the Radio Research Board. The site is in the grounds of the Admiralty Compass Observatory at Ditton Park, where nearly 100 acres have been available for field experimental work for many years past. In addition, the Ministry of Works has purchased another 100 acres of the neighbouring farm. This additional land has been acquired mainly to ensure that the whole site is kept free from undesirable electrical interference with the radio research work. A very small portion of it may be used for further experimental work; but apart from this, the additional land will continue to be available to the farmer. The building has been designed by the architects of the Ministry of Works specifically to meet the requirements of the Radio Research Station. A two-story administrative block together with the workshops, stores, dining-room and all general services are concentrated at one end of the building. The scientific and technical laboratories are contained in a single-story building with a main block and four spurs, the ends of which open directly on to the field, which is regarded, for radio experiments, as a continuation of the laboratory working-space. Every effort is being made to restrict the metalwork installed in the field so that the minimum of disturbance is caused to experimental work. In order to reduce to the minimum the radio interference from the ignition systems of motor traffic,

the building site is more than 200 yards from the nearest road; and most of the working parts of the fields in use are nearly half a mile from any public road carrying vehicular traffic. In cases where the research work is of a type that cannot be conducted inside the building, provision is made for the use of a number of huts of a temporary and transportable nature. The present staff of the Radio Research Station, all in temporary accommodation, is just over a hundred, and it is expected that this will be considerably increased when the new building is ready for occupation.

Metallic Corrosion: an Instructional Film

A 16-mm. coloured film entitled "Corrosion in Action", originally made in the United States under the auspices of the International Nickel Company, Inc., is now available in Britain and can be borrowed for educational or other purposes from the Mond Nickel Company, Ltd. (Thames House, Millbank, London, S.W.1). The film, which lasts for sixty-four minutes, has to a certain extent been edited for British consumption, the main change being a new sound-track with an English-accent commentary. Each topic begins from first principles but rapidly builds up to intermediate and even degree level. The economic importance of the general corrosion of metals is first explained, and then a short historical survey leads to a diagrammatic explanation of electro-chemical corrosion, oxygen being emphasized as a promoter of cathodic reactions. The arrangements of metals in their electromotive series introduces a discussion of galvanic action in terms of potentials, current density and area effects, and this is shown in a series of laboratory tests utilizing colour-changing reagents which detect the existence of anodic and cathodic corrosion products. Passivity and protective films are demonstrated by a series of bench experiments, indicating how important the film can be in some instances. Local shielding and the damage resulting from it are followed by a section comparing the mechanism of corrosion of various materials. The film ends with illustrations of the measures that can be taken to minimize corrosion and the importance of choosing materials in the light of the full knowledge of the many factors in individual corrosion problems.

Agricultural History Review

Within a year of its inauguration, the British Agricultural History Society has issued the first volume of its official publication, the *Agricultural History Review*. The Society was founded to bring together those interested in agriculture as a living, historical process, whether their sphere of activity lay in academic institutions or in the countryside. The new publication should do much to promote this aim, and its appearance is timely in view of the rapid changes that have been taking place in rural life and practice during the mid-twentieth century. Each issue will contain a number of articles embodying original research in agricultural history, together with shorter notes and comments, a bibliography and book reviews. The following titles of the articles in the first number, each of which is contributed by a well-known specialist, give some idea of the scope of the publication and the potential wealth of suitable subject-matter: some traditional farming beliefs in the light of modern science; the poll tax and census of sheep, 1549; the Isle of Axholme before Vermuyden; agricultural returns and the government during the Napoleonic Wars; a Cornish farmer in Ontario, 1830–71. The *Review* is issued only to members of the Society (c/o Museum of English Rural Life, 7 Shinfield Road, Reading; 1 guinea a year). The first number contains sixty-four pages, and at least two issues annually are anticipated.

Bird Study

As in every other science, progress in ornithology is very dependent upon publication. This point is well brought out by Major-General H. P. W. Hutson, chairman of the British Trust for Ornithology, in the foreword to a new journal which has recently been launched by the Trust (*Bird Study*, **1**, No. 1; March 1954). The first issue contains an article by J. F. Monk on the breeding of the greenfinch and another by D. Lack describing observations made on robin populations in Oxford and south Devon. The Rev. P. H. T. Hartley has contributed a stimulating and unusual article on back-garden ornithology which should be most encouraging to would-be bird observers. The journal also contains a section illustrating recent activities of the British Trust for Ornithology. The production of this journal is of good standard, although one misses the attractive photographs which have become a marked feature of other bird journals.

Institution of Mining and Metallurgy: Awards

The Institution of Mining and Metallurgy has recently made the following awards: *Gold Medal of the Institution*, to Mr. Essington Lewis, president of the Fifth Empire Mining and Metallurgical Congress, in recognition of his long and distinguished services to the mining and metallurgical industries of Australia; *The Consolidated Gold Fields of South Africa, Limited, Gold Medal*, to Dr. J. S. Webb, for his work on the development of geochemical prospecting methods; *The Consolidated Gold Fields of South Africa, Limited, Premium of Forty Guineas*, to Mr. R. Daniel, for his paper on diamond mining practice in Kimberley, South Africa (*Trans.*, **62**); *Arthur Claudet Student's Prize*, to Mr. T. A. Henderson, for his part authorship of the paper on some exploratory experiments on the formation and control of magnetite during copper smelting operations (*Trans.*, **62**); *William Frecheville Student's Prize*, to Mr. C. L. Hall, for his part authorship of the paper on laboratory tests on the concentration of witherite from the northern Pennines by froth flotation (*Trans.*, **62**). Honorary membership of the Institution has been conferred on Mr. Thomas Pryor, past-president of the Institution, in recognition of his services to the Institution and to mining education.

Nuclear Physics Conference in Glasgow

An international conference on experimental and theoretical nuclear physics will be held in the Department of Natural Philosophy of the University of Glasgow during July 12–17, under the general chairmanship of Prof. P. I. Dee. This conference is sponsored by the International Union of Pure and Applied Physics and the United Nations Educational, Scientific and Cultural Organization, and is one of similar conferences on various topics which are held each year in a country of the United Nations Organization. It is fitting that Glasgow should be chosen as the meeting place, as this year has seen the opening of the new Nuclear Physics Building, housing, among other apparatus, the largest synchrotron in Europe. There will be about three

hundred delegates to the conference, representing twenty-six different countries. During the conference lectures will be given on the outstanding problems of nuclear science, with particular reference to the part played by mesons in nuclear forces, and it is hoped that the interchange of information and ideas between physicists from different parts of the world will result in some of these problems being solved. Further information can be obtained from the secretary of the conference, Dr. K. G. McNeill, Department of Natural Philosophy, University, Glasgow, W.2.

Colonial Service: Recent Appointments

The following appointments have recently been made in the Colonial Service: G. W. Anderson (agricultural officer, Zanzibar), agricultural officer, Uganda; R. N. Coster (agricultural officer, Fiji), agricultural officer, Sierra Leone; M. Lunan (agricultural officer, Tanganyika), regional assistant director of agriculture, Tanganyika; R. K. Tremlett (agricultural officer, Uganda), agricultural officer, Zanzibar; N. Kirby (deputy government chemist, Jamaica), government chemist, Jamaica; E. W. March (conservator of forests, Jamaica), conservator of forests, Nigeria; J. D. Arnead (medical officer, grade *B*, Trinidad), pathologist, grade *B*, Trinidad; W. R. E. Nanton (agricultural officer, Grenada), superintendent of agriculture, Windward Islands; B. C. Akehurst and H. W. Mitchell, agricultural officers, Tanganyika; J. R. Watkins, geologist, Uganda; Miss M. M. Bools, pathologist, Sierra Leone; Miss H. T. Brash, soil survey officer, Gold Coast; A. E. Green, senior British laboratory technician, Rockefeller Foundation Regional Virus Laboratory, Trinidad; D. P. Hinton, agricultural officer, Northern Rhodesia; H. W. Ord, economist/statistician, Kenya.

Announcements

Prof. B. F. J. Schonland, director of the Bernard Price Institute of Geophysics and Carnegie-Price professor of geophysics in the University of the Witwatersrand, has been appointed deputy director of the Atomic Energy Research Establishment, Harwell.

Dr. D. B. Spalding, University demonstrator in engineering in the University of Cambridge, has been appointed to the University of London readership in applied heat tenable at the Imperial College of Science and Technology.

A research scholarship worth £400 a year for two years has been offered by the Aluminium Development Association to encourage and facilitate research in the application of light alloys to ship construction. The scholarship will be administered by a committee of the Institution of Naval Architects, and it is hoped to make an award in September this year. Further particulars of entry, which closes on June 30, can be obtained from the Secretary of the Institution, 10 Upper Belgrave Street, London, S.W.1.

The Bermuda Biological Station has recently received a grant covering a period of five years from the United States National Science Foundation. These funds, which are immediately available, will be awarded mainly as fellowships to pay for research space, living expenses or special collecting facilities required while at the Station; applications for aid in purchasing equipment or necessary travel expenses may also be considered. A booklet describing the Bermuda Biological Station, and application forms for the fellowships, can be obtained from the director, Dr. William H. Sutcliffe, jun., Bermuda Biological Station, St. George's West, Bermuda.

The centenary of the birth of Henri Poincaré, mathematician and philosopher, will be celebrated in Paris during May 15–17. Further ceremonies will be held in Nancy on May 22 and later in Caen. Further information can be obtained from Le Comité d'organisation du Centenaire, Amis de l'École Polytechnique, 17 rue Descartes, Paris 5e.

The Meteorologische Gesellschaft in Hamburg will be holding a meeting in Hamburg during October 4–6 in honour of the centenary of the birth of G. Hellmann. Papers not longer than fifteen minutes in duration will be read, and such contributions must be submitted (with a short summary) not later than July 1 to the Meteorologische Gesellschaft, Bernhard-Nocht-Strasse 76, Hamburg 4, from which further information can be obtained.

The Institute of Chemistry of Ireland is holding a summer school in organic chemistry in University College, Dublin, during July 6–9. Four lectures will be given on the fundamentals of the subject and two lectures on each of the following: newer methods and reagents; electrophoresis; analysis; distillation; chromatography; and spectrophotometry. The fee for the course is one guinea for members of the Institute and two guineas for non-members (students 10s.). Application forms and further information can be obtained from the Secretary, Institute of Chemistry of Ireland, 18 Ely Place, Dublin.

The Royal Institute of Chemistry is arranging a symposium on recent advances in the chemistry and industrial applications of cellulose, to be held in the University of St. Andrews during June 28–July 2. The symposium will consider three topics: chemistry of cellulose; paper and pulp; and industrial applications of cellulose and its derivatives. Further information can be obtained from the Assistant Secretary, Royal Institute of Chemistry, 30 Russell Square, London, W.C.1.

A conference on soil microbiology will be held at Purdue University during June 21–24, sponsored by the American Society of Agronomy, the Soil Science Society of America, and Purdue University. There will be major sessions on the following topics: physical properties of soils as affected by microbial activities; soil organic matter maintenance; organic matter transformations; and frontiers in soil microbiological research. Further information can be obtained from Lewis W. Erdman, Plant Industry Station, Beltsville, Maryland.

Fifty years ago the first paper dealing with oxide-coated cathodes was published, and to celebrate this anniversary the Société Française des Ingénieurs Techniciens du Vide is organizing an international convention to be held in Paris during June 24–25. The programme will be in six parts, dealing with the following topics: metal base; carbonates and coating process; emission theory of oxide-coated cathodes; definition of the cathode properties; special cathodes; and stability of emissive properties. The texts of the papers to be read will be published in a special issue of the journal *Le Vide*. Further information can be obtained from the Société Française des Ingénieurs Techniciens du Vide, 44 rue de Rennes, Paris 6e.

THE TRAINING OF BIOLOGISTS

A DISCUSSION on the training of biologists, organized by the Institute of Biology, was held in London during April 21–22. The first session, under the chairmanship of Mr. J. F. Wolfenden, vice-chancellor of the University of Reading, was opened by Miss R. Hemmings (Girls' High School, Burton-on-Trent). She stressed the poor background from which the majority of the pupils at maintained schools come, and their ignorance, when they leave the primary schools, of any foreign language or mathematics, and of the principles of clear thinking. These deficiencies make the process of giving them a broad education both slow and difficult, and this in its turn reacts on the teaching of science. The careers which the girls follow vary widely; but teaching is not favoured. Mr. G. B. Hindle (King's Norton Grammar School for Boys) spoke of the great improvements that have taken place during the past twenty-five years in laboratories, text-books and the technique of teaching. This has been accompanied by a big increase in sixth-form numbers, and at King's Norton the use of the science sixth as a school of liberal education is encouraged. Mr. Hindle felt that professional biologists of the experimental type could be made if one started at the sixth-form level or even later, but that the training of field naturalists should begin much earlier. The shortage of qualified staff is an obvious difficulty, and while it was his opinion that pass-degree men were seldom of much use for sixth-form work, they could be helpful in the middle school.

Mr. W. H. Dowdeswell, describing conditions at Winchester College, said that biology is not begun until the sixth-form stage is reached, and this works well, at least with fairly able boys. Much emphasis is placed on field-work, about one-seventh of the total class-time being spent on this. A great handicap in making the subject live is that text-books, although so full of facts that they are difficult to read, do not treat the organisms as living creatures; they describe, for example, an abstract 'earthworm', in apparent ignorance of the fact that there are in Britain about a dozen species of different structure, habits and distribution. Mr. C. Bibby (College of St. Mark and St. John, London) balanced the wide range of initial knowledge of his students, from zero to degree standard, against the great freedom which the training colleges have to arrange their own courses.

The subsequent discussion ranged over a wide field. Points which were made by more than one speaker were that a chief duty of schools is to give a liberal education, and that many teachers keep much too closely to the syllabus and the text-book, in the mistaken belief that that is the only way to get their pupils through examinations. In answer to a question, Dr. G. E. Fogg said that the present over-production of pass-degree and third-class honours men unsuitable for teaching is not so large as had been predicted.

At the next session Dr. R. K. S. Wood (Imperial College of Science and Technology, London) gave a summary of the replies received to a questionnaire recently circulated by the Institute of Biology to heads of university departments. About two-thirds of the botany and zoology departments replied, and in nearly all there is some specialization in the final year; but while in botany the number in which some choice is given is about the same as that in which all the special courses are compulsory, in the majority of zoology departments the student has some choice. A slight majority of the zoological heads think that this specialization ought to be reduced to a minimum; but nearly all the botanists accept it as inevitable and desirable.

Undergraduate courses in botany, plant physiology and zoology were dealt with by Dr. J. Heslop-Harrison (University College, London), Prof. F. G. Gregory (Imperial College of Science and Technology, London) and Dr. J. A. Kitching (University of Bristol), respectively. All three liked their students to have read chemistry, physics and mathematics instead of biology at school, although Prof. Gregory restricted this preference to those who would become research workers. Dr. Heslop-Harrison asked if it would not be better for future teachers and such-like to read pass degrees, so that all honours students could stay on and do postgraduate work. Prof. Gregory made a plea for the education of biological administrators—an important and increasing class. Dr. Kitching described the course at Bristol, where systematic zoology is compressed into one year and much attention is given to field-work and such special subjects as cytology and embryology.

Prof. J. F. Danielli (King's College, London) spoke on the other biological subjects and described the two ways of teaching biochemistry: as an undergraduate subject to students who have physics, chemistry and mathematics but know no biology, and as a postgraduate course for chemists or biologists. He said that the outstanding problems are the failure of the universities in general education and of the schools to attract outstanding teachers. A partial reason for the second of these was given in the subsequent discussion when Mr. D. A. Sturdy (Felsted School) said that if the universities do not want the schools to teach biology it is unlikely that the schools could attract good teachers. Prof. F. R. Winton (University of London) said that students must be allowed to study a subject when they are interested in it, a view which was applauded, and Dr. Wood that if biology were excluded from the schools there would soon be no biologists. Mr. W. B. Yapp (University of Birmingham) said that the trouble with insisting that future biologists should read chemistry, physics and mathematics in the sixth form is that the Advanced Level syllabuses in these subjects do not contain the material which they need.

The third session dealt with biology in technical colleges. Mr. S. A. Smith (London School of Hygiene and Tropical Medicine) described the courses for the examinations of the City and Guilds Institute and of the Science Technologists Association, and Dr. H. F. Steedman the special courses in biological technology which are run in the University of Glasgow. Both types of course were welcomed by speakers from the floor. Prof. I. A. Preece (Heriot-Watt College, Edinburgh) spoke on the need for a National Certificate in Biology, which would give a more theoretical qualification for such technicians as those responsible for routine testing in factories. Miss J. E. Heriot (Brighton Technical College) spoke on the difficulties and successes of technical colleges in

their degree work. In a lively discussion which followed, there was support for the idea of a National Certificate, and the difficulties in training isolated technicians, including those in schools, were stressed.

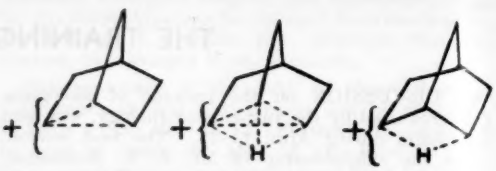
The final session dealt with postgraduate training. Summarizing the replies to the Institute's questionnaire, Dr. Wood said that few departments give any special courses in research methods, and that neither in botany nor zoology is it common for there to be concentration of the main resources of a department on a narrow field of inquiry. Dr. G. E. Fogg (University College, London) described a postgraduate course in microbiology, and Dr. G. Brownlee (King's College, London) a similar course in pharmacology. Both these consist of lectures and practical work. Prof. V. B. Wigglesworth (University of Cambridge) spoke on the Ph.D. and gave as his opinion that, in spite of its obvious disadvantages, this degree is on the whole worth while; but that employers should not insist on it. He deprecated the publication of theses, and Sir James Gray in the discussion went further and recommended their abolition. Dr. J. Y. Bogue (Imperial Chemical Industries, Ltd.) included, in his summary of the qualities which are desirable in the industrial research worker, a first-class education in the broadest sense, an ability to handle technicians and an ability to write English. The importance of the last was stressed by a number of speakers in the discussion, and other points that were made were that there might be scope for part-time postgraduate courses, and that workers who do not live in university towns are greatly handicapped by lack of library facilities. W. B. Yapp

MOLECULAR REARRANGEMENTS IN ORGANIC CHEMISTRY

ON April 6 a symposium was held by the Chemistry Department of Queen Mary College, London, on "Molecular Rearrangements in Organic Chemistry". Prof. D. H. Hey took the chair. The seven contributions covered those features of molecular rearrangements which are of current interest and stimulated a lively discussion.

Prof. S. Winstein described his investigations of 1 : 3 and 1 : 2 hydrogen shifts in carbonium ions. Roberts and Lee[1] had established the existence of a 1 : 3 hydrogen shift in the non-classical *nor*bornyl carbonium ion; Prof. Winstein has found that the hydrogen shift does not accompany formation of the ion but occurs in a subsequent step. The first ion to be formed is the non-classical structure (I), and the subsequent migration involves as intermediate either the *nor*tricyclonium ion (II), or the alternative structure (III). Prof. Winstein favoured the latter alternative. He then described experiments in the cyclohexane series which demonstrate the possibility of anchimeric assistance of ionization by adjacent hydrogen atoms, the ionization of appropriate cyclohexyl esters occurring more rapidly than would be anticipated and with a 1 : 2 shift of hydrogen.

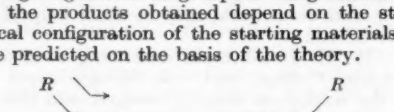
In the subsequent discussion, Dr. H. Cardwell suggested that anchimeric assistance by adjacent hydrogen might be general in S_N1 solvolyses and pointed out that, if this were so, a statistical correction should be applied to observed solvolysis-rates, depending



(I) (II) (III)

on the number of hydrogen atoms able to participate. This idea was criticized by Prof. Winstein on experimental grounds. Prof. H. C. Longuet-Higgins gave theoretical reasons in support of the structure (III) for the *nor*bornyl intermediate. Prof. M. J. S. Dewar emphasized that, although anchimeric assistance of solvolysis implies greater stability of the π-complex form of a carbonium compound with the classical form, the converse is not necessarily true. After further discussion, the consensus of opinion seemed to be that anchimeric assistance of solvolysis by hydrogen does not occur, except in special cases, but that the π-complex ions with hydrogen in the non-classical position are probably more stable than isomeric classical structures.

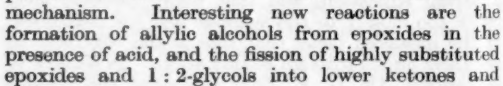
Prof. C. W. Shoppee discussed the stereochemistry of Wagner rearrangements in terms of the mechanism suggested by Ingold and Shoppee[2]. In the rearrangement (IV), inversion should occur at both carbon atoms α,β, and retention of configuration in the migrating group *R*. Prof. Shoppee described a number of rearrangements in the sterol series, involving migrations of groups or ring contraction, where the products obtained depend on the stereochemical configuration of the starting materials and can be predicted on the basis of the theory.

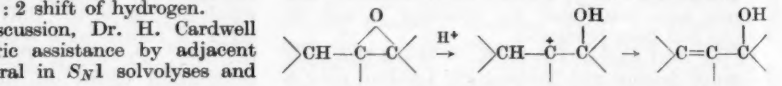


(IV)

Prof. Winstein pointed out that these conclusions are somewhat too rigid; while the configuration of *R* is invariably retained, and while C_α and C_β commonly undergo inversion, cases are known where retention of configuration can occur. He pointed out that the stereochemical course of the reaction depends on the timing of the individual processes; in particular, exclusive inversion at C_β occurs as a rule only when there is anchimeric assistance of the ionization of *X*.

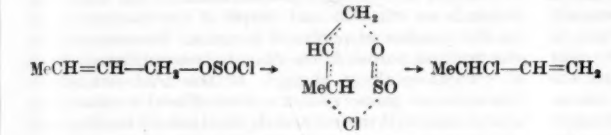
Dr. W. J. Hickinbottom then described a number of investigations into the course of rearrangements of epoxides and related glycols. These were interpreted in terms of the current carbonium ion mechanism. Interesting new reactions are the formation of allylic alcohols from epoxides in the presence of acid, and the fission of highly substituted epoxides and 1 : 2-glycols into lower ketones and olefins. These reactions were interpreted as follows:





Whether or not the rearrangements of epoxides take place via intermediate glycols is being investigated.

The second session was devoted to anionotropy. Prof. W. G. Young described the reactions of allyl alcohol derivatives with thionyl chloride. Under conditions where intervention of chloride ion is avoided, the reactions proceed with rearrangement via cyclic transition states (S_Ni' mechanism), for example :



In the presence of chloride ion, an alternative S_N2 reaction leads to unrearranged chloride. By suitable choice of the reaction conditions, either unrearranged chloride, or rearranged chloride, can be obtained. An S_N1 reaction can also be observed in ionizing solvents, the product from either isomeric alcohol then being an identical mixture of the two chlorides.

Dr. E. A. Braude reviewed the historical development of the concept of anionotropy, and emphasized the role of acid catalysis. He then described a reinvestigation of the rearrangement of α-phenylallyl *p*-nitrobenzoate into cinnamyl *p*-nitrobenzoate in the presence of isotopically labelled *p*-nitrobenzoic acid in chlorobenzene solution. It was shown that the reaction occurs by two distinct paths, one involving an internal rearrangement (cf. (IV)) and one a bimolecular reaction with the added acid. Both reactions are catalysed by acid. Dr. Braude concluded that no free allylic cations are involved as intermediates, the bimolecular process being of the S_N2' type ; and that free allyl cations are probably not involved in anionotropy (see also *Nature*, May 8, p. 863).

Prof. S. Winstein criticized Dr. Braude's conclusions on the grounds that free ions cannot in any event occur in the solvent used, and that the work described is consistent with the initial formation of an ion-pair, which can either rearrange by 'internal collapse' or react with *p*-nitrobenzoic acid. He thought that free ions might well participate in more polar solvents. A lively discussion followed, on the distinction between ion-pair mechanisms and mechanisms involving cyclic transition-states. The conclusion appeared to be that ion pairs and covalently bound cyclic intermediates are not qualitatively distinct, but form extremes in a graded series (cf. the relation between covalent and ionic bonds). In this case the experimental evidence does not lead to a clear distinction.

The final session dealt with rearrangements in the aromatic series. Prof. E. D. Hughes outlined a general classification of reactions in which groups migrate from the side-chain to the nucleus in an aromatic system. He concluded that the main types of mechanism are an intermolecular process of the S_N1 or S_N2' type, and an intramolecular process, giving *o*-substituted aniline derivatives via cyclic transition states. The rearrangement of N-phenylhydroxylamine was cited as an example of the former, and the rearrangement of N-nitranilines, and the reaction of aniline with sulphur trioxide, as examples of the latter.

Prof. M. J. S. Dewar outlined the various types of rearrangements that occur in aromatic systems, and emphasized the difficulty of determining whether or not they are intramolecular. If they are, classical mechanisms will not suffice, for the rearrangements often occur between widely separated centres. He outlined the π-complex mechanism for such processes and applied the idea to the rearrangements of N-bromoacetanilide and of hydrazobenzenes. Fresh experimental evidence was cited which suggested that the former reaction is intramolecular ; and a general survey of the available evidence was held to support the mechanism in the case of hydrazobenzene derivatives. In the subsequent discussion, his conclusions concerning the mechanism of the N-bromoacetanilide rearrangement were strongly criticized and strongly defended.

It was generally agreed that the symposium had been of value both in presenting various points of view and in clarifying ideas. A remarkable measure of agreement was reached on most of the controversial issues.

M. F. Ansell
M. J. S. Dewar

[1] Roberts, J. D., and Lee, C. C., *J. Amer. Chem. Soc.*, **73**, 5009 (1951).
[2] Ingold, C. K., and Shoppee, C. W., *J. Chem. Soc.*, 365 (1928).

FRICTION IN RELATION TO RHEOLOGICAL PROPERTIES

ALTHOUGH a number of theories of solid friction have in the past been proposed, the one which has been most fruitful and most widely accepted in recent years is the adhesion mechanism of friction originally developed for sliding metals. According to this model, metals, when placed in contact, touch only at their high spots, and the local pressures are usually sufficient to produce plastic flow. At these regions strong adhesion occurs by a process which may be called cold welding. The strong junctions thus formed must be sheared if sliding is to occur, and this is primarily the source of the frictional resistance. With metals the deformation of the asperities is primarily plastic. Under these conditions the area of contact is proportional to the load and independent of the size of the bodies, so that the friction, too, is proportional to the load and independent of the size of the bodies (Amontons's laws).

The reality of junction formation is shown by examining the friction tracks, which provide clear evidence of welding and shearing. This raises the interesting question as to why normal adhesion is not observed between metals. Although contaminant films may be partly responsible, the main effect appears to be due to released elastic stresses which peel the surfaces apart as the joining load is removed, so that little or no normal adhesion is detected. With soft ductile materials such as indium, where the metal can take up changes in shape of the surfaces as the load is removed, large adhesions are observed.

Clean Metals and the Influence of Oxide Films

If metal surfaces are thoroughly denuded of oxide films, Amontons's laws no longer hold. Because the surfaces are clean, they adhere strongly wherever they touch and the sliding process itself produces a very marked growth of junctions. Under favourable conditions, junction growth may proceed until the

whole of the geometric area is in intimate contact. Gross seizure occurs and ordinary sliding is almost impossible. The presence of small amounts of oxygen, however, enables sliding to occur and the friction is essentially the same as for surfaces prepared in the atmosphere.

The detailed effect of the surface oxide film depends upon the relative rheological properties of the oxide and the metal substrate. If the oxide is hard and the substrate soft, the condition is like a layer of ice on mud. Penetration takes place readily and good metallic contact occurs. The friction is high and the surface damage heavy. If, on the other hand, the oxide is ductile and can flow with the deformed underlying metal, it is better able to maintain its integrity. The friction and surface-damage may be small for moderate deformation; for sufficiently heavy deformations the surface film may be ruptured with a corresponding increase in friction and wear.

The behaviour of aluminium is of particular interest since the oxide is hard and the metallic substrate soft. Consequently, as we should expect, the thin natural oxide film offers little protection to the underlying metal. Some improvement may be obtained by artificially increasing the thickness of the oxide film by anodic oxidation. These films are, in fact, more resistant to rupture than the natural films. At small loads they maintain their integrity and the friction and surface-damage are small. With increasing load the films first fail in tension as a result of the tangential frictional forces produced during sliding. At greater loads gross disintegration of the film occurs. The frictional properties of the films depend on the surface roughness. In addition, their porosity may play an important part in trapping lubricant and so reducing the friction and wear in lubricated sliding.

Brittle Solids

The two main features of the theory of metallic friction are that cold welding occurs at the interface and that, because plastic flow takes place, the area of contact is proportional to the applied load. With brittle materials it would seem at first sight that neither of these conditions is applicable. A detailed study shows, however, that the local pressures around the individual regions of contact are sufficient to prevent brittle fracture and there is considerable *plastic* flow at the interface. As a result, although some surface fragmentation may occur, the behaviour is dominated by the plastic deformation of the surface layers. In addition, under the influence of high pressures and plastic flow, strong interfacial adhesion occurs. Consequently, the mechanism derived for metals is applicable; the friction is proportional to the load and of the same order of magnitude as for metals.

The high pressures existing at the points of real contact also play a very important part in boundary lubrication. The lubricant film which is sheared during sliding is subjected to pressures comparable to the yield pressure of the metal (for steel about 200,000 lb./sq. in.). Under these conditions, the resistance of the film to shear and penetration is enormously increased.

Plastics and Fibres

Other classes of materials to which the adhesion mechanism of friction may be applied are long-chain polymers, plastics and fibres. The deformation of these materials is not, however, as clearly defined as for metals. At high loads the area of real contact is roughly proportional to the load, so that Amontons's laws are obeyed. At light loads this is no longer so. The coefficient of friction is no longer constant but increases steadily as the load is reduced. Interferometric studies show that the deformation of the surfaces is more nearly elastic than plastic. The area of contact is no longer proportional to the load, and depends on the size and shape of the specimen and on the number of points of contact. Because of this, the friction across fibres may be very different from the friction along them. If the material shows visco-elastic properties, the area of real contact at a given load will increase with the time of loading and there is a corresponding time dependency in the friction.

These and other issues relating elastic, plastic and visco-elastic properties of materials to their frictional behaviour were discussed at a symposium convened by the British Society of Rheology on February 26, on "Friction in relation to Rheological Properties". Dr. L. R. G. Treloar presided and the three main papers were given by Dr. D. Tabor, on the "Effect of Some Physical and Rheological Properties on the Friction and Lubrication of Solids", Dr. H. J. Howell on "Friction and Surface Deformation in Fibres" and Dr. F. H. R. Wright on "Frictional Behaviour of Anodic Films on Aluminium Surfaces".

D. Tabor

SCIENCE IN THE UNITED STATES

THE sixth of the annual reviews produced by the British Commonwealth Scientific Office in North America, entitled "Science in the U.S.A. for the Year ended June 1953"*, follows much the same lines as that for the year ended June 1952, which was the first to be openly published (see *Nature*, **172**, 282; 1953). In its sections on the expenditure of the Federal Government on research and development, on industrial research and development, and on university and non-profit research, it draws extensively on reports issued by the National Science Foundation. A section on scientific and technological man-power is likewise based on two reports, "Student Deferment and National Manpower Policy" and "A Policy for Scientific and Professional Manpower", issued by the National Manpower Council; these are to be followed by a third, "A Policy for Technical and Skilled Manpower". The second of these reports estimates that, of the five millions now engaged in scientific and professional work, more than a million are teachers, nearly a million are engaged in medical and health services and more than half a million are engineers; but of 155,000 workers in natural science, about 15,000 are engaged in fundamental research. Shortages in different branches of science are regarded as qualitative as much as quantitative, and it is recommended that no attempt should be made to urge school leavers to turn to particular branches of study in conformity with a predetermined national policy. Instead, expansion over the whole field of higher education is suggested, so as to overcome the

* British Commonwealth Scientific Office, North America. The BCSO Review of Science in the U.S.A. for the Year ending June 1953. (United Kingdom Scientific Mission, Canadian Scientific Liaison Office, Australian Scientific Liaison Office, New Zealand Scientific Liaison Office, South African Scientific Liaison Office.) Pp. iv+44. (London: H.M.S.O., 1954.) 2s. net.

shortages without destroying the overall balance between different disciplines, and employment practices which cause inefficient utilization of professional man-power, especially in engineering, are deplored.

During the year, new restrictions were placed on the flow of unclassified reports from the Department of Defense, which is itself financing more than a third of all scientific research in the United States, and these are likely to impede the free exchange of technical information between the United States and other countries. On March 16, 1953, the two original documentation centres of the Department of Defense were amalgamated to form the Armed Services Technical Information Agency. This Agency is expressly forbidden to make even unclassified material available except for military purposes, and those engaged in defence research are entitled to receive material only in those subject categories for which they have proved a need. Furthermore, the Agency is not to undertake the direct collection of information from foreign sources or to disseminate information to foreign governments, their nationals or representatives. Much of the unclassified material is afterwards published; but now that the services provided by the Technical Information Division of the Library of Congress are no longer available to foreign countries, delays of twelve months or more may be experienced before such information becomes available. The report points out that direct exchange between institutions may now be the best avenue still open through the International Exchange Service at the Smithsonian Institution; this, however, is limited by the small funds available and the consequent necessity of using the cheapest form of freight transport, with delays normally of several months.

It is not too difficult, however, to obtain unclassified reports from some Federal departments. The Atomic Energy Commission has always fully implemented the charge laid upon it by the United States Atomic Energy Act "that the dissemination of [unclassified] scientific and technical information relating to atomic energy should be permitted and encouraged so as to provide that free interchange of ideas and criticism which is essential to scientific progress", and the report directs attention to the wide range of the physical and biological sciences covered by the publications of the Commission and listed in *Nuclear Science Abstracts*. Expenditure on the Commission's programme during the year ended June 30, 1953, is estimated at 4,000 million dollars, of which about 300 million was spent on research and development. Most of the section dealing with atomic energy in this report is concerned with the development of nuclear power for industrial or domestic purposes. In a statement issued on May 26, 1953, the Commission proposed interim legislation to permit non-government ownership and operation of nuclear power facilities, the use and transfer of fissionable and by-product materials under suitable safeguards, and the granting of more liberal patent rights than is possible at present. It also proposed to allow research and development on specific power projects to be undertaken in the laboratories of the Commission, and that a progressively liberalized information policy should be applied in the power reactor field. The objective of this policy is to further the development of nuclear plants which are economically independent of government commitments to purchase weapons-grade plutonium.

During the past year it has become evident that commercial rain-makers are losing business, but interest and activity in the physics of rain and cloud formation has greatly increased, with the growing realization of the importance of tackling fundamental physical problems first. Work continued on the theoretical and practical aspects of the use of radar in cloud detection and of radar echo-intensity measurements in the estimation of rainfall. The importance of coalescence as a mechanism in rain formation was increasingly appreciated, and the report notes a more positive attitude on the part of the United States Weather Bureau toward cloud seeding: experimental work was to start this spring in the State of Washington.

In radio astronomy, Ewen and Purcell's discovery of hydrogen-line radiation from outer space has not been followed up, although the Carnegie Institution of Washington will shortly bring into operation an extended Wurtzberg antenna, with Ewen-type receiving equipment. Practically no 'radio star' work has been done, but three prominent 'radio nebulæ' have been identified with astronomical objects that can be 'seen'.

On April 14, 1952, a complete table of assignments covering the very-high-frequency and ultra-high-frequency bands was released, and there is considerable activity in the development of ultra-high-frequency receivers. The design of the high-power output stage presents the most difficult transmitter problem; and in colour television, while the Columbia Broadcasting System frame sequential method is at present the officially authorized system, the door has been left open for any other system that can be demonstrated successfully.

Capital expenditure of the chemical industry during the year is estimated at 1,500 million dollars, and this includes plant capable of producing 30 million lb. of orlon a year; 50 million dollars for new plant in New Orleans for acetylene, ammonia and acrylonitrile, and expanded facilities for the production of aureomycin; a 1·8 million dollar plant for dextran, a blood plasma substitute; a 14 million dollar project for defluorinated phosphate, one by-product of which will be uranium; and 7 million dollars for a plant for phenol by the new cumene process. Plans were also announced to spend more than 700 million dollars on new plants in Texas, Louisiana, Oklahoma and Arkansas, and increasing attention is being focused on the study of water pollution and atmospheric pollution accompanying the establishment of heavy industries. Probably the most interesting development in the plastics field is the production of new semi-permeable ion-exchange membranes in two forms, which permit the passage of anions or cations, respectively; it appears most improbable, however, that the demineralization of sea-water by such processes will be economically attractive, but with brackish waters the position is more promising.

In fuel technology a final report from the National Petroleum Council maintains the view that neither the hydrogenation nor the Fischer–Tropsch process approaches a cost competitive with gasoline from crude petroleum at 12 cents per U.S. gallon; oil shale is the only alternative source that could be considered commercially. Sufficient progress is claimed with development of low-temperature fluidized carbonization for the design of a full-size industrial unit. Development work on the hydraulic transport of fine coal has been completed, and this

method is regarded as an economic proposition with a 12-in. bore pipe-line over distances of 50–200 miles. In building, the report notes the trials made with hydraulically operated back-acting diggers thought to be suitable for digging foundations and drainage trenches; with the 'vacuum-processing' of concrete and the 'vacuum-lifting' of concrete units; and with the Tournalayer system of building, in which the concrete shell of a house is cast at a central point on a building site, and then carried away and placed on its foundations.

In mechanical engineering, considerable interest has been stimulated in the hot-forming and machining and grinding of titanium alloys, and in electrical processes for shaping and finishing hard materials, and increased attention is being given to the characteristics of machined surfaces. There has been an enormous growth of research in applied mechanics, and growing interest is also noted among engineers in the science of management and in the application of operational research to management problems. In metallurgy the shell-moulding process has attracted further attention; but phenol – formaldehyde resins continue to be the only ones of industrial importance as binders when casting alloys of relatively low melting point like those of aluminium. The production of nodular cast iron continues to increase, and American foundries are now investigating the effect of adding cerium simultaneously with magnesium to neutralize the harmful effects of residual elements.

EUROPEAN PRODUCTIVITY AGENCY

FIRST ANNUAL PROGRAMME OF ACTION

THE summary of the first annual programme of action of the European Productivity Agency, published by the Organization for European Economic Co-operation, Paris, points out that a campaign to increase productivity sets both technical and psychological problems, the latter being the more difficult and important. Some of the sociological effects of technological advances may be wholly beneficial, but others, such as the need for the worker to adapt himself to new processes or new trades, may cause temporary individual problems and require careful study. Resistance to change is not confined to labour; and it is important for it to be known that, under European conditions, higher productivity in the long run means increased possibilities of employment and that any temporary risk of technological unemployment is far less grave than that facing a community which allows itself to fall behind others in the efficient use of its resources. With proper co-operation between management and labour, even technological unemployment can be avoided, if everything is done to increase the speed of adaptation to new tasks by improving vocational training and to facilitate mobility of labour by housing policy and efficient labour-exchange services.

As regards general policy, the summary indicates that the Agency aims at giving an initial impetus to groups which can show a reasonable chance of continuing and developing with fresh sources of support and at making these continuing projects self-supporting to the maximum extent. The programme is summarized under six main headings: specific economic and legal problems; technical and administrative problems of industry and commerce; human factors of management and labour; applied research and technology; food and agriculture; and information and general services. Under the second heading, action is contemplated to bring European management to a wider understanding of the need for management education, and the creation or development of chairs of business administration in European universities and technical colleges. Further research is also proposed on the factors determining the attitudes of employers and employees to the scientific study of the selection of workers and conditions of workers, and the pooling of experience and effort in training supervisors.

In applied research and technology, the Agency's task is essentially to supplement what is being done in existing institutions, to co-ordinate such research and to strengthen the liaison between research and industry—for example, by facilitating contacts for exchanges of information and views between those in charge of the organization and administration of research. An essential task will be to improve existing channels for disseminating technological information and the study and development of new media. The establishment and development of specialized research and information centres in the main industrial sectors will be encouraged, and special attention will be given to increasing technological productivity in the building industry.

The Agency's efforts to improve productivity in the field of food production and agriculture will be directed towards the study of the economic organization of the farm as a production unit; the factors of input in agriculture, horticulture and fisheries; the marketing and distribution of output; techniques in production processes in these fields; and the exchange of information and techniques of communication.

TRIBUTE TO PROF. ALEXANDER LIPSCHUTZ

THE combined second and third numbers of Vol. 3 of *Acta Physiologica Latinoamericana* contain a series of thirty-one essays by distinguished contributors, offered as a tribute to Prof. Alexander Lipschutz on his seventieth birthday*. The articles are variously written in English, Spanish, French, Portuguese and German. The first, by B. A. Houssay, is a laudatory biographical sketch of Prof. Lipschutz; the remainder cover a wide range of subjects—reproductive and general physiology, cancer, steroid chemistry, and numerous miscellaneous biological matters—in most of which Prof. Lipschutz has himself been an active investigator. To summarize all these interesting essays is not possible in this short review; to single out a few for special mention must place the reviewer in an invidious position. His own interests, not the excellence of the articles chosen, can be the only criteria of choice.

Prof. Lipschutz enunciated the law of follicular constancy in 1930, and two papers are directly concerned with this. M. and C. Aron discuss the nature

* *Acta Physiologica Latinoamericana*. Vol. 3, Nos. 2 y 3: Numero de Homenaje al Profesor Alejandro Lipschutz. Pp. vi+49–202. (Buenos Aires: Asociacion Ciencia e Investigacion, 1953.) n.p.

of the reactionary hyperactivity in the remaining ovary after unilateral ovariectomy and the factors involved in its genesis. S. Zuckerman summarizes the recent researches in his department on the question of oogenesis in adult animals and concludes that this does not occur in the rat, rabbit or monkey, though it may in the lemur, armadillo and guinea pig. Another paper with some bearing on this subject, though with far wider significance also, is that by A. S. Parkes on the conservation of gonadal tissue by deep freezing after glycerol treatment. Such tissues, after apparently indefinite storage, may behave much like fresh material on grafting.

There are a number of papers dealing with cancer research. F. Bielschowsky, discussing the influence of the ovaries on the production of chemically induced cancers, states that mammary cancers were obtained in nearly as high an incidence in rats bearing ovarian grafts as in intact animals, and that such tumours developed whether the graft formed corpora lutea or not. B. A. and A. B. Houssay, A. F. Cardeza, V. G. Foglia and R. M. Pinto describe the adrenocortical tumours which develop slowly in white rats after gonadectomy. Many of these tumours eventually elaborate œstrogens, under the influence of the pituitary gonadotrophins. A. Lacassagne, L. Hurst, F. Zajdela and R. Royer, writing on the experimental production of cancer of the liver, conclude that there is no sex difference in susceptibility, and that œstrogens decrease the susceptibility, while castration of the male, the administration of testosterone to castrates of both sexes, or of progesterone to castrate males, increases it. A brief paper by Peyton Rous reviews cancer research over the years.

Problems relating to the action of reproductive hormones are considered in another group of papers. John Hammond writes on the effect of the plane of nutrition on hormone action, and on the curious way in which uterine infections in cattle occur much more readily under the influence of progesterone than of œstrogens. F. J. A. Paesi, E. M. van Soest and S. E. de Jongh conclude that androgens take no significant share in the development of the secondary sexual characters of the female rat. C. D. de Pasqualini describes the effects of adrenal grafts in adrenalectomized rats; in such animals there is luteinization of the ovaries or hyperplasia of the Leydig cells of the testes. Some abnormality of function of the adrenal graft appears to lead to the secretion of excessive amounts of pituitary luteinizing (or interstitial-cell-stimulating) hormone. The relations between the gonads and the adrenal cortex are also discussed by A. D. da Costa. Gregory Pincus and M. C. Chang confirm the effectiveness of progesterone as an inhibitor of ovulation in the rabbit, and they also discuss the effectiveness of other related steroids.

Among the papers on steroid chemistry, R. Courrier writes on the allenolic series of artificial œstrogens, E. C. Dodds on the relation of stilbœstrol to naturally occurring œstrogens, and Christian Hamburger on the ultra-violet absorption spectra of œstrogens. K. Miescher, A. Wettstein and F. W. Kahnt demonstrate the conversion by adrenal homogenate of 9 : 11-dehydro compound-S acetate into its 11-β-hydroxylated derivatives (17-hydroxycorticosterone and its acetate), and this finding, they conclude, strengthens the supposition that 9 : 11-dehydro-steroids may represent important intermediates in the metabolism of the adrenal cortical hormones.

Other essays in this interesting collection deal with aspects of diabetes (V. G. Foglia; O. Koref, L. Vargas and A. Vukusic); cardiac activity (B. Gunther; F. Hoffmann, S. Middleton, A. Molina and J. Talesnik; O. Orías); hormonal factors in the development of inflammation (H. Selye); the discovery of uterine smooth muscle (G. W. Corner); histochemical reactions of mast cells (W. Buño); and a variety of other topics including renin, the cytology of urinary sediment as an indicator of œstrogenic stimulation, respiratory control, motor nerve section, the neurovegetative system, and certain factors influencing the voluntary intake of alcohol by rats.

G. I. M. Swyer

FORESTRY IN THE SUDAN

THE annual report for July 1951–June 1952 of the Forest Department of the Sudan* is a very full and discursive document of sixty-nine pages and deals with many sides of what should be wholly the work of the forest officer alone. As an introduction, the report states "the brief description of the distribution and main uses of the forests which has been included in previous reports is repeated here". The statement of the forest policy in force, laid down in 1932, which is given in full in chapter 2 of the report, defines the division of responsibility between the Chief Conservator and governors of Provinces. The latter are responsible "for ensuring that the permanent supply of forest produce is sufficient to meet the internal requirements of their Provinces". Governors are, moreover, "empowered to declare as Provincial Reserves such areas as they consider necessary"; they are "to prepare programmes in accordance with their estimated future provincial requirements and engage staff to carry them into effect". It might be logically asked—What is the Forest Department for? The statement adds that "expenditure in this connexion will be borne by province budgets and that Governors may refer to the Chief Conservator for advice".

The Chief Conservator writes in this annual report that "twenty years have now elapsed since this policy was laid down and it is timely to review results. They are not wholly satisfactory." The provincial forests made by Governors during the period only amount to one thirty-seventh of the area of the reserved forests owing to the very natural preoccupation of provincial administration staffs with other duties and a lack of appreciation of the fact that forestry is essentially a long-term business. A revealing comment from the report is that "forestry is so dwarfed by State Agriculture in the Sudan that it is not often realized that the scale of all-round forestry here is now greater than in other African territories of comparable resources", and, it might have been added, though the forestry staff is much smaller.

The wonderful success of the Gezira undertaking placed the Agricultural Department in its present position in the administration of the Sudan. Had the gum arabic, a purely forest product, been placed under the management of the Forest Department as it logically should have been, the annual revenue received, a considerable portion of the Sudan's

* Sudan Government. Forest Department of the Ministry of Agriculture: Report for the Period July 1951 to June 1952. Pp. iv+70. (Khartoum: Ministry of Agriculture, Forest Department, 1953.)

annual budget, instead of being credited to the district revenues would have come to the Department. The latter would have had long ago sufficient strength to put in force the urgent variety of work which, the report shows, is now being attempted. If it is necessary to train the forester for his duties, it follows that they cannot be carried out, nor even fully understood, by other elements of the administration. The striking example is the collection of the valuable gum arabic by the people under the ægis of the civil administration to which, as has been said, is credited this valuable revenue. It brings to mind the old days, during two-thirds of the last century in Madras, when the revenue authorities considered that the forest officer could only exercise his duties in the heavy timber forests, chiefly situated in the western half, and that he had no jurisdiction in the scrub forests in the eastern half of the Presidency, the produce of which was credited to the district revenue with no supervision over its collection. The points of view of the Governor-General and the Secretary of State for India in this matter were at length accepted by Madras, and all forests and their products, including timber-producing or scrub valuable for firewood and grazing and some other minor products, were placed under the Forest Department and all revenues therefrom credited to that Department. It is not too much to believe that, had the gum arabic product been placed under the Forest Department in the Sudan even as late as 1932, the methods of collection and regulation of the so-called 'gardens' would have long ago been under a working plan and a larger annual revenue could be now realized (see para. 179 of the report).

With the comparatively recent expansion of the work during 1951–52, 496,469 feddans of new reserves were gazetted, bringing the total of reserved forest up to 722,553 feddans (1,173 square miles), which seems very little to show for fifty years of work. But taking areas under reservation, the area totals 3,051 square miles, representing 0·314 per cent of the total area of the Sudan. It is noted in the report that Uganda has already more than 7 per cent of reserved forest. In knowledgeable quarters it is judged that 15 per cent of well-distributed forests is none too much for safety in an arid tropical country. A very considerable amount of planting has been carried out during the year, a large planting campaign having been organized.

The staff of the Department amounts to twenty officers (two under training in the United Kingdom) and seventy-six in the subordinate ranks, other than forest guards, who are not mentioned. If this staff was doubled it would scarcely be able to carry out all the duties facing a Forestry Department entrusted by its Government to undertake all the forestry work in the country. Enumeration surveys of all forests of commercial value, in which saw-mills appear to be multiplying, and, perhaps even more important, investigations into the ownership of supplies from which the large demands for firewood and charcoal are being obtained, would appear to be urgent. For example, one reads in the report on this subject: ¶"For the southern division the Conservator writes of the increased prosperity in Khartoum Province, reflected in much building with an accompanying increase in the demand for firewood to burn the bricks. The demand far exceeded the supply of firewood imported by the Department into Khartoum Province on rail, with the result that the illicit cutting of desert 'scrub' forest showed an unwelcome increase, although no widespread devastation took place." Who is to be the ultimate sufferer through the "illicit cutting of the desert 'scrub' forest"? Moreover, who is the authority directly responsible? Is it the Forestry Department?

In the seventies of the last century a somewhat similar situation arose in the so-called *rukhs* in the Punjab plains, covered by a desert scrub, on account of its use for firewood. The newly building railways demanded wood fuel for running the engines and wished to have the exclusive use of the scrub; the calculations of the possible available amounts included digging out and utilizing the roots, thus ensuring a resultant desert. This was prevented by placing the management of the *rukhs* under the management of the Forest Department, which, as the Secretary of State said, had been brought into the administration and trained for the purpose of undertaking this type of work. E. P. Stebbing

ROBERT JAMESON AND THE ROYAL SCOTTISH MUSEUM, EDINBURGH

A PAPER by Mr. V. A. Eyles on "Robert Jameson and the Royal Scottish Museum", published in the April issue of *Discovery*, is particularly appropriate in view of the centenary this year of the Royal Scottish Museum, Edinburgh, for it was through Jameson's enthusiastic labours in the College Museum that eventually it attained such a status that it was taken over by the State. In a foreword, Mr. Eyles describes the origin of the University of Edinburgh and its relationship to the civic authorities. He then records the circumstances of the establishment of the chair of natural history and its progress under Dr. Robert Ramsay, Dr. John Walker and Robert Jameson, who succeeded in 1804.

The professor of natural history was *ex officio* keeper of the Museum, and Jameson, in addition to a long and distinguished career as a naturalist, was also zealous in his care of the collections. Eventually geology became his chief subject, and he was caught up in the great Huttonian–Wernerian controversy. He studied under Werner in the mining town of Freiburg for nearly two years; and Eyles records that he "absorbed uncritically all that he [Werner] had to say" and eventually became the greatest protagonist for Wernerism in Britain. But his enthusiasm for geology did not mean the neglect of the other branches of natural history, for he lectured on meteorology, hydrology, mineralogy, geology, botany and zoology—truly a formidable list. The general impression among his students, including Charles Darwin, was that the lectures were rather dull but accurate, and unrelieved by any humour or figures of speech.

As a museum man, Jameson experienced all the trials of a present-day curator, including lack of accommodation and funds. In 1852 Jameson prepared a report on the Museum, and eventually the collections were accepted by the State in 1854. The foundation-stone of the Royal Scottish Museum in Chambers Street was laid by the Prince Consort in 1871. All interested in the history of geological studies and their influence on contemporary thought are indebted to Mr. Eyles for his painstaking paper.

BOOK REVIEWS

CELL PHYSIOLOGY

Pathology of the Cell

By Prof. Gordon Roy Cameron. Pp. xv + 840 + 64 plates. (Edinburgh and London: Oliver and Boyd, Ltd., 1952.) 84*s*. net.

As text-books on a major subject like pathology get increasingly larger they tend to become reference books and few students can be expected to read them from cover to cover. Many books of this kind are in essence scarcely more than carefully systematized descriptions of abnormal microscopic and macroscopic structure. The sequence of the chapters, though often varied with considerable ingenuity, does little to conceal the essential sameness of the information. It is indeed difficult to present a major subject in an entirely new way because systematization and the burden of accumulated facts allow almost no scope at all for the broader concepts and freedom of treatment characterizing many works in the literature of biology as a whole.

Prof. Gordon Cameron has written a book of monumental size and quite exceptional scholarship. It is not a conventional text-book of pathology or a standard work of reference on morbid histology, but a very fascinating story in which function and structure in disease have been linked with what is known about normal and abnormal cells. The text consists of four parts: the normal cell, the abnormal cell, a critique of the cell theory and cellular pathology in the future.

In the past decade or so cellular physiology has undergone amazing progress. It is everywhere predominant in this book, the material of which ranges from plants and protozoa to man. The author deals extensively with the historical development of the cellular theory which some may hesitate to read fully because there is so much else which commands attention in the more familiar modern era of the subject, or perhaps because not everyone can be as deeply interested as the author in the philosophies of the German nineteenth-century science. Each chapter, however, has a concise summary and so one can delve deeply or superficially as the spirit moves.

Prof. Cameron is no pundit concealing the sources of his knowledge for the sake of brevity or elegance of style. In fact, this book might almost be said to be excessively documented to the extent of being difficult or uncomfortable to read. This is a fault not of style but of the technique in correlating the reference lists with the text. If each paper quoted had been given a serial number inserted quite inconspicuously at each appropriate point in the text there would have been no need to interrupt some sentences with a list of authors' names and dates, sometimes extending over half a page.

The chapters on cellular degeneration and inflammation are especially noteworthy for a functional, rather than a morphological, approach. The vital biological process is envisaged rather than the static pathological state. But clearly the author is restless for the fruits of the almost unlimited field which the investigation of the sub-microscopic normal and abnormal structure is bound to provide. The pathology of the future, which is outlined in Part 4 of this book, is both imaginative and stimulating.

There are more than six hundred pages of text, with an excellent bibliography and subject index. The numerous illustrations are well reproduced, but a few of them appear to have been inserted more as an afterthought, marrying somewhat awkwardly with the text.

Written over a period of eleven years this book cannot fail to be a source of constant inspiration to research pathologists and biologists. It is indeed a remarkable achievement. E. S. Horning

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SOCIAL BEHAVIOUR OF BIRDS

The Herring Gull's World

A Study of the Social Behaviour of Birds. By Dr. Niko Tinbergen. (The New Naturalist Series.) Pp. xvi + 255 + 30 plates. (London: William Collins, Sons and Co., Ltd., 1953.) 18*s*. net.

This is a fascinating book. It consists of a detailed account of the ordinary behaviour of a common bird; but it is full of scientific interest in the physio-psychological analysis of these activities. It is rigorously objective and exact in its treatment; but its clear expositions are pleasantly free from all but a minimum of technical terms. The only subjective note that is allowed to intrude is one of keen enjoyment on the part of the investigator; and that the reader will find infectious.

Here modern ideas of animal behaviour, on which Dr. Tinbergen—formerly of Leyden, now of Oxford—is a distinguished authority, are exemplified in a single species. The behaviour of the herring gull is minutely followed throughout the season when close observation is possible, from first arrival at the nesting colony, through pairing and incubation, to the phase of family life. That the author is one of those students of behaviour who prefers to make his observations in the field rather than the laboratory, even when experimental methods are used, will earn the sympathy of readers who are primarily naturalists.

The herring gull's world is seen to be governed by a few major drives or internal urges. Under the influence of whichever predominates at the time, the bird shows a delicate sensitivity to special external stimuli and a capacity for reacting to these by corresponding special types of behaviour. When the response to a particular stimulus is innate, it is rigid and almost automatic, unilluminated by insight into the ends served: the reaction to hard food is to fly up with it and drop it from a height; but experience brings no awareness that the food must be dropped on hard ground for the behaviour to be effective. Yet, in other cases, a reaction may be 'conditioned' by learning: the bird quickly learns to recognize its own mate, and learns to recognize its own chicks (although never its own eggs) within about five days.

One of the reactions most closely studied here is that of the chick seeking food by pecking at the red spot on its parent's beak. Experiments with dummies of various shapes, sizes, patterns and colours demonstrated how definite this is. The response is indeed evoked by a red spot when presented without any-

thing otherwise resembling beak or bird; and the chick may repeat it hundreds of times in spite of failure thus to obtain food. It is even possible to evoke a "supernormal" response by exaggerating the feature; and in this regard the author cites woman's use of lipstick as an analogy.

Much that is most puzzling in the behaviour of birds becomes explicable in terms of 'displacement activities', in accordance with what Edmund Selous long ago called "the law of the interchangeability of energies". When an urge is frustrated, it finds an outlet in some action belonging to quite a different context—like the cat, suddenly unsure of itself, which stops to wash its face. These irrelevant actions are often characterized by being incomplete and may become stereotyped in a ritual form. Actions of this type make up a large part of the behaviour of birds, and not least in those species which are markedly social in the reproductive phase of their lives.

The interesting explanation is offered of the pair's defence of 'territory' around the nest, in the case of a colony on open ground, that dispersion adds to the value of the cryptic coloration of eggs and young. The observed effect of predation is indeed a wider spacing of the nests when the birds lay again.

Dr. Tinbergen frankly enjoys wresting secrets from the living things which he studies. He likens his pleasure to that of the chase: "I am not in the least ashamed," he says, "to confess that my photographs and this book are my trophies." Many will gain by examining them.

Landsborough Thomson

NATURAL HISTORY OF THE PINKFOOT GOOSE

A Thousand Geese

By Peter Scott and James Fisher. Pp. 240 + 17 plates. (London: William Collins, Sons and Co., Ltd., 1953.) 21*s*. net.

THE late Gino Watkins once quoted to us: "When a man really wants to do a thing, he will succeed". Peter Scott certainly demonstrates the fundamental truth of this seemingly sweeping statement. Urged by a deep-rooted interest in water fowl, almost bordering on an obsession, he has managed to bring together a unique collection of live Anatidae on the New Grounds near Slimbridge, has travelled widely for the purpose of collecting and observing out-of-the-way species, and has recently embarked on a very ambitious population study of the pinkfoot, a goose wintering mainly in Britain and breeding in the Arctic. This idea was conceived at a time when it was not yet known for certain where the main breeding colonies of the species were.

At first, in the late 'forties, the geese were captured (with the now famous rocket-net technique), ringed and otherwise marked on various wintering grounds in England and Scotland; but in 1950 Scott decided to go to the heart of Iceland where, he had strong reasons for believing, the largest breeding colonies must be found.

Together with Miss Philippa Talbot-Ponsonby (now Mrs. Scott), the well-known Icelandic ornithologist Finnur Gudmundsson, and James Fisher he set out in June 1951, and in the beginning of August returned, having found the large colonies which he knew must be there, having made provisional counts, and having ringed 1,151 geese—a remarkable achievement.

"A Thousand Geese" is the narrative of this expedition, written in a simple, straightforward style, which brings out the atmosphere of such a delightfully single-purposed enterprise, during which a man, while working hard, can get a good mental rest by living close to Nature.

In a footnote at the end of the book Scott adds that he went again in 1953 and that this time, using the experience gained in 1951, he caught 9,005 geese. According to his estimates about "one in five of the world pinkfoot population now carries a ring". The repeated sampling makes calculations of the Iceland population possible, and the large-scale ringing will provide valuable data on various aspects of pinkfoot population ecology. Excellent planning, great tenacity of purpose, and exceptional skill has enabled him to make this admirable start.

Apart from the story, the book contains, in an appendix, detailed information on the status of the pinkfoot in Spitsbergen, on its status in Greenland, notes on the birds observed at the camp site, a list of plants found (compiled by Gudmundsson), estimates of the local pinkfoot population, and a bibliography of the breeding distribution of the species.

The illustrations are excellent, and special mention should be made of the very attractive book-jacket.

N. Tinbergen

A HANDBOOK FOR BIRD-RINGERS

Bird-Ringing

The Art of Bird Study by Individual Marking. By R. M. Lockley and Rosemary Russell. Pp. viii + 119 + 8 plates. (London: Crosby Lockwood and Son, Ltd., 1953.) 9*s*. 6*d*. net.

R. M. LOCKLEY is a pioneer of British bird observatory work, and few ornithologists can have exceeded his total of birds personally ringed. He also has many European correspondents in this field, and his collaborator, Mrs. Russell, has had recent experience of North American 'banding' methods. Their first three chapters are written most entertainingly and describe the history, value and technique of bird-ringing succinctly but with interesting illustrations. At the same time, there is a needed emphasis on care. Bird trapping and ringing have become enormously popular in recent years and have attracted a large number of enthusiasts with little previous knowledge of ornithology. But birds are delicate organisms, and it is essential scientifically—as well as most desirable on humane grounds—that they should be caused as little discomfort as possible when they are caught and afterwards handled.

More than half the book is taken up with illustrated descriptions of traps and other catching devices. This is quite reasonable. Provided the need for care and gentleness is realized, the actual process of ringing a bird is simple and, in any event, can only be learnt in the field. The real art lies in catching the bird. Most of the designs have already appeared in the first field guide of the British Trust for Ornithology (1950) by P. A. D. Hollom, but the authors have various developments and modifications to record and add some useful American patterns excluded by the Trust's booklet.

The final chapters deal with recording and field equipment, and glance at the ancillary techniques of weighing, measuring and parasite collection. A full list of the British bird observatories makes an important appendix. The authors exclude, however, any detailed references to ringing outside the British Isles on the grounds that the literature received was "far too voluminous"; but a list of the more important schemes would have been welcomed and could have replaced the four pages devoted to a "Model Life-Study by the Ringing Method". Some of the works mentioned in the text by abbreviated titles are not recognizable in the "Select Bibliography", which includes remarkably few titles directly relevant to ringing methods and thus at least shows the need for this well-produced little handbook.

BRUCE CAMPBELL

WEST AFRICAN "BEEF"

The Overloaded Ark

By Gerald M. Durrell. Pp. 238. (London: Faber and Faber, Ltd., 1953.) 15*s*. net.

THIS is an account of a collecting trip to West Africa by two naturalists who were determined to go to the tropics and enjoy the wild life of them, but who could raise the necessary money only by undertaking to collect wild animals for European zoos. They came back poorer financially than they left; but they did manage to cover the greater part of their expenses, and they were enormously enriched by their experiences. Gerald Durrell and his companion, John Yealland, are excellent naturalists, and the first, who, against the advice of the second, has written this book, has the flair for writing that runs in the family and has produced a most entertaining volume.

The steaming forests of the Cameroons teem with animal life if only you can find it; but the human collector toiling painfully on foot through the tangled undergrowth is at a great disadvantage compared with the animals that can creep under the obstructions, swing from tree to tree over him, or soar into the air above everything. By enlisting the help of the natives who have been born and bred in the forest it is, however, possible to come up with the wild creatures and to capture specimens of "beef", as the wild animals of the region are called in the local pidgin.

The author and his companion were able to get together a good collection of birds and animals—perhaps the most interesting of them all were the angwantibo and the otter shrew. The angwantibo, *Arctocebus calabarensis*, is a very rare lemuroid found only in the forests of the British and French Cameroons; there are very few specimens in museums, and it had never been brought alive to Europe. Scarcely a single zoologist had ever seen it alive, and practically nothing was known of its way of life. After much fruitless searching a native casually brought one in, caged in a basket of palm leaf; it placidly accepted captivity and was successfully brought to the London Zoo. *Arctocebus* much resembles the potto; it is nocturnal, spending the day asleep clinging to a branch with its head tucked down between its arms, becoming active at night and feeding upon fruit, insects and meat. Durrell was also fortunate enough to obtain two otter shrews, or giant water shrews (*Potamogale*); but after they had apparently settled down comfortably in captivity they both inexplicably died. The account of the finding and capture of the first in the middle of the night under a rock in a mountain torrent is a splendid bit of descriptive writing, as indeed are many other passages in the book. The natural diet of the otter shrew appears to be freshwater crabs, for of all the food-stuffs offered they were the only things eaten. The author was able to wean them on to an artificial diet which seemed to suit them well until their sudden deaths showed that something was lacking. Such are the delights and disappointments of the animal collector.

This is an excellent travel book that really gives the reader the feel of the tropical forests of West Africa; it is vivid but objective, and avoids purple passages—it will fill naturalists with envy of those whose enterprise took them on such a fascinating zoological journey. The skilful line drawings by Sabine Baur are an ornament to the work.

L. HARRISON MATTHEWS

CULTURE OF ALGAE

Algal Culture

From Laboratory to Pilot Plant. Edited by John S. Burlew. Pp. ix+357. (Publication 600.) (Washington, D.C.: Carnegie Institution of Washington, 1953.) 1.25 dollars.

IT has not often happened that a scientific programme of uncertain outcome, which is only worthwhile if it has practical results, has attracted so much attention, so many fertile brains and even very considerable funds. In biology it has happened for the first time.

The reason is the obvious necessity to supplement our normal field-crops, which cannot be increased much above the present level, with some kind of food of a different origin. The rising number of inhabitants of the earth, due to reduced mortality, puts pressure on our inventive capacities, and one hopes to find a way out with the help of algal cultures.

Conforming with the general tendency of our time to plan ahead, means and energy are being directed towards growing algae on a gigantic scale which, twenty years ago, would have appeared ridiculous to propose. Compared with the food value of the algae hoped for, the transformation of radiant energy plays a minor part in the discussions.

At present the solar energy reaching the earth is, to a large extent, wasted. No better means for utilizing it is known than the pigment system of green plants, and it seems more reasonable to use the algae produced, if sufficient quantities are forthcoming, as a food for man and animals than to burn them in boilers. The notion of growing algae as food was conceived in Germany by O. Warburg during the First World War, but did not begin to stimulate action until the Second World War, and then mainly in the United States, while minor efforts are reported from Great Britain, the Netherlands, Israel, Germany and Japan.

The main aim is to attain optimum utilization of radiant energy from the sun; the main difficulty being the protection against infection with other, for example predatory, organisms. A closed, though not necessarily sterile, apparatus of enormous dimensions is required. One hopes to produce a larger amount of

dry organic matter with algae than with customary field-crops which cover the ground and form an almost uninterrupted photosynthetic layer only during a short part of the year.

A great effort is directed towards the elucidation of the main factors in algal growth and reproduction, for example, the effect of light-intensity, temperature, different nutrient solutions, density of cell-suspension, intermittent light, etc. At the same time, the dimensions of the experiments are steadily increased, from test-tubes and flasks to large bottles and so on, eventually to pilot plants.

So far no alga has proved superior to *Chlorella pyrenoidosa* in productivity; but it seems possible that other properties may in future play a part: among others, easier harvesting, hardiness against high temperatures as caused by insolation, or against chemical admixtures to the ordinary agricultural fertilizers which will have to replace the pure chemicals now in use.

The contributions by various authors are of unequal value. Those who believe that pure cultures are not indispensable for achieving heavy yields continuously are in the minority but not yet defeated, although their achievements are not impressive. Some new discovery may alter that. There is a great deal of information in this volume which will stimulate research in many ways. E. G. Pringsheim

PLANT GENERA

Plant Genera

Their Nature and Definition. A Symposium by G. H. M. Lawrence, I. W. Bailey, Arthur J. Eames, Reed C. Rollins, Marion S. Cave and Herbert L. Mason. With an introductory essay on Generic Synopses and Modern Taxonomy by Theodor Just. (Chronica Botanica, Vol. 14, No. 3.) Pp. 91–160. (Waltham, Mass.: The Chronica Botanica Co.; London: William Dawson and Sons, Ltd., 1953.) 2 dollars.

THE genus occupies an important place in the hierarchy of taxa. Historically, it was recognized as a reasonably clear concept before the species or the family. Nomenclaturally, it is the basis for the manufacture of most family names and forms the specific name in combination with the specific epithet. Phytogeographically, the ranges of genera provide data (and problems) that are often of greater significance than those yielded by the ranges of species or families. There are thus valid reasons for periodically reviewing the generic concept.

The symposium on plant genera to which notice is given here was apparently largely initiated by Dr. F. Verdoorn, the editor of "Chronica Botanica", who contributes a foreword in which he pleads for "a national or international scheme which will result in the preparation of a complete, somewhat uniform, series of generic floras".

In an introductory essay Theodor Just notes that we now recognize the need for different kinds of genera and, while supporting the scheme for generic floras, shows that these must be prepared by long-term team work. G. H. M. Lawrence refers to various taxonomic "trouble-spots" and declares his belief "that the answers will not be found, until we taxonomists function as synthesizers, until we focus on each problem all the pertinent data to be had from related fields of botanical effort". This emphasis on what has been called synthetic taxonomy is increased by other contributors, as by I. W. Bailey in an anatomical approach, A. J. Eames for floral anatomy, R. C. Rollins with regard to cytogenetics, M. S. Cave for cytology and embryology, and H. L. Mason in dealing with the role of plant geography in taxonomy.

As many of the writers clearly point out, no one set of criteria, no group of characters from a restricted field can alone result in a widely satisfactory delimitation of genera (or other taxa). The difficulties, practical and theoretical, of utilizing diverse 'characters' in taxonomy are not to be gainsaid. Much modern work has shown that they can be overcome and that the results can be expressed, at least to a very large extent, within the existing framework of taxonomy. Subsidiary schemes are often useful if only temporarily and within narrow limits, but no general replacement of the species–genus–family hierarchy has yet been proposed and tested to meet with wide acceptance.

The idea of preparing "generic floras" or "genera plantarum" to include all cryptogams and phanerogams needs careful consideration. Genera are composed of species and, concretely, species are composed of individuals. It may be argued that delimitation of genera should succeed, not precede, the study of the species involved. In other words, if the modern methods of synthetic taxonomy be accepted, monographic work is essential before the genera can be satisfactorily determined. There is a danger in deciding on generic criteria and generic limits without fully examining every species and ultimately every available specimen and all data. It is true that a genus can often be adequately determined without settling every specific and intraspecific nomenclatural problem but not without fully studying the 'characters' of, and within, all the species and specimens available. The question then arises: "Is it not worth while spending the extra time and properly monographing the group?"

W. B. Turrill

CHEMISTRY OF TISSUE SECTIONS

Histochemistry

Theoretical and Applied. By Dr. A. G. Everson Pearse. Pp. viii+530+35 plates. (London: J. and A. Churchill, Ltd., 1953.) 60*s*. net.

AS Dr. Pearse says in his preface: "Histochemistry can transform the descriptive sciences of biology into dynamic and functional sciences". His book "is an endeavour to compass the whole of histochemistry as applied to tissue sections".

The book opens with a short chapter on the history of histochemistry, followed by a discussion of fixation and freeze drying. Then proteins, nucleic acids, carbohydrates, lipids, carbonyl compounds, various enzymes, pigments and inorganic constituents are treated in succession, and to conclude there are brief chapters on physical methods and appendixes, compiled in cookery-book style, on histochemical procedures.

To write a text-book on a subject which is still in its early stages of development is to offer many hostages to fortune. What fortune will do with them remains to be seen. In the meantime this book constitutes intelligent comment on the present position in histochemistry, which will be of interest

to all who are concerned in the scientific development of the field. The appendixes will be appreciated by the many workers who are beginning to make empirical use of histochemical methods.

The discussion in this book is most valuable when it is concerned with problems in organic chemistry and biochemistry, and is notably weak on the physical side. Since the main intention of the author is to facilitate qualitative and diagnostic studies, which depend on chemistry rather than physics, the weakness on the physical side is not of major importance.

The chapter on freeze drying is the best of the physical sections. For the most part it wisely follows the recent publications of L. G. E. Bell, and where it deviates is liable to error: for example, on p. 36 the dryer manufactured by Edwards and Co. is classified among the outmoded vapour-trap dryers, whereas it is an approximation to a mean free path dryer. The discussion of diffusion errors is very limited in its scope. The chapter on physical methods devotes less than two pages to the techniques of visible and X-ray spectrophotometry, doing quite inadequate justice to the work of Caspersson, and not mentioning the valuable contributions of Wilkins and other members of the King's College biophysics group. There is also a tendency to underestimate the importance of the work of a number of authors, for example, Brachet, Bourne, Caspersson, Chèvremont and Verne, and perhaps to be overkind to the present reviewer. These faults, however, are minor in relation to the author's purpose.

This work has a double interest, being of value both to those who wish to develop histochemistry as a precise scientific tool and also to those who wish to use histochemical methods in a manner analogous to histological procedures. The usefulness of the latter point of view is sometimes under-estimated. It does not matter, for example, that a histologist does not know exactly why a section stains with hæmatoxylin and eosin, provided the results he obtains are repeatable and assist diagnosis in a reliable way. Similarly, a histologist may use histochemical techniques for staining sections and will be justified if he is thereby assisted in diagnosis. Whether the method is a precise one on the chemical and cytological level may be irrelevant.

J. F. DANIELLI

MALE STERILITY

La Sterilità nel Maschio

Fisiopatologia degli Organi della Riproduzione. Diagnostica e Terapia dell'Infertilità Maschile. Da Guglielmo Longo. Pp. xix+520. (Salerno: Diffusion Scientifique Internationale, 1953.) 4000 Lire.

GYNÆCOLOGY is a branch of some antiquity in medical science: its counterpart, andrology, has been practically non-existent as such until relatively recently; in fact, it is only beginning to emerge in emancipation from general medicine, endocrinology and urology. The reason for this may be sought, partly at least, in the circumstance that in the not so distant past the blame for involuntary conjugal sterility has been conventionally apportioned to women, nearly all earlier attempts at clinical investigation having been resisted and scornfully rejected by the 'stronger' sex. However, for some time now, it has been dawning upon clinicians and scientific observers alike that, in a hitherto unsuspected proportion of cases—at least 25 per cent of the total number of sterile marriages—it is the male partner whose sterility or subfertility lies at the root of the trouble.

Quite apart from these considerations, recent years have witnessed an upsurge in scientific, socio-economic and medical interest throughout the entire field of human reproduction; this being amply reflected in the formation in most countries of the world of learned societies concerned with the study of fertility and sterility in the human race. Thus, in Great Britain there exists the Society for the Study of Fertility, which publishes annually its Proceedings; and in the United States, the American Society for the Study of Sterility, which publishes the periodical *Fertility and Sterility*, occupies a similar position.

The aim of Dr. Longo's treatise on sterility in the male is twofold: (1) to co-ordinate and disseminate modern knowledge in the field of human reproduction; (2) to focus the attention of his medical colleagues upon the responsibility of the male partner in marital sterility. The book is composed of four parts, of which the first deals at length with the anatomy of the male reproductive tract, physiology of reproduction, including its sex–psychological aspects, semen morphology, and endogenous and exogenous factors which influence semen characteristics; the next part is concerned with more specifically clinical aspects of male infertility due to anatomical or endocrinological causes; Part 3 is a survey of clinical and laboratory methods of semen evaluation, pp. 397–441 offering a detailed account of current methods of semen analysis; the last part of the book is devoted to preventive and therapeutic measures to be adopted in cases of male subfertility; a brief outline of the technique of testicular biopsy and vasopuncture is included.

The literature is conscientiously quoted and the author is equally appreciative of European and American scientific work. The text is lucidly written so that it is possible to follow without difficulty the gist of each section even if, like the reviewer herself, one can claim but limited knowledge of Italian. Some of the illustrations would doubtlessly benefit from the use (in a future edition) of higher quality paper. Coming from the home of some of the most illustrious pioneers in the field of reproduction, to name only Malpighi, Spallanzani, Mantegazza, Sertoli, Dr. Longo's is an effort thoroughly worthy of the tradition established in Italy by those early investigators and actively maintained by the present generation of scientific and medical research workers.

C. LUTWAK-MANN

COMPARATIVE PHYSIOLOGY OF ANIMAL PIGMENTS

Animal Biochromes and Structural Colours

Physical, Chemical, Distributional and Physiological Features of Coloured Bodies in the Animal World. By Dr. Denis L. Fox. Pp. xiv+379+3 plates. (Cambridge: At the University Press, 1953.) 60*s*. net.

IT is unusual indeed for a work on animal colours to be as comprehensive as this latest review by Prof. D. L. Fox. The compression of a vast amount of material into a limited space can so often result

in a treatise of interest only to the specialist. But in this case the author's conciseness, his first-hand knowledge of so wide a field in this domain and, above all, an enthusiasm born of æsthetic appreciation of the wonderful diversity of natural coloration have yielded a work which will command interest throughout, and even beyond, the realm of biology.

The author has himself made notable contributions to our knowledge of structural colours in animals, and his authoritative discussion is a welcome addition to the rather infrequent reviews of this fascinating subject. Many readers will no doubt be surprised to learn of the extent to which structural colours occur as a result either of scattering (Tyndall blues) or of interference at a laminated surface (iridescence of birds and insects). Further examples are found in the 'structural whites' of butterflies, while the elytra of the genus *Serica* carry an accurately ruled diffraction grating with 0·8-μ spacing. A preliminary account of the physical basis of colour is given in terms which, though elementary, are adequate for an appreciation of the colour-producing tegumentary structures of which numerous examples are described.

That the chapter on carotenoids is the largest is scarcely surprising in view of the author's eminent position in this field. While the chief emphasis is on comparative physiology, useful but necessarily brief discussions of carotenoid chemistry and of isolation methods are included. A great difficulty in surveying these pigments lies in the multiplicity of reports on their isolation and their prompt naming after the animal origin. To classify the numerous synonyms and to produce a balanced review requires a deep inside knowledge of the development of carotenoid studies. There is no doubt that the chapter will be regarded as an outstanding contribution to our knowledge of these pigments.

A survey of tegumentary colouring is essentially completed by an account of the indole pigments. Apart from the striking Tyrian purple these pigments come mainly under the heading of melanins, a series of ill-defined grey to brown pigments which offer little attraction either as biochromes or as problems for the chemist. However, they play interesting parts in cephalopod inks and as the dark backgrounds essential for the full brilliance of Tyndall blues.

While the preceding pigments are biochromes in the true sense inasmuch as they so often appear to be produced for adornment, others have a more utilitarian role and add little or nothing to external coloration. Of the latter type the most widespread are the tetrapyrrols and in particular the derivatives of hæmatin. It is unfortunate that the introductory chemical survey of these pigments lacks the conciseness of the rest of the book. No elementary account of hæmatin compounds is possible unless the underlying significance of the ferrous–ferric relationships and the distinctive properties of derivatives at the two levels of oxidation are made clear. Such a statement as "the older, rather indefinite term haematin is approximately equivalent to haem" obscures the whole basis of these relationships. Furthermore, the statement that the "exact function [of the cytochromes] in the organism remains yet to be described" completely contradicts the extensive and precise information now available on their respiratory function.

Shorter chapters provide useful summaries on chromolipoids, quinones, anthocyanins, flavones, purines, pterins and flavins. The latter group scarcely qualify as biochromes, their interest being purely metabolic. However, it would be desirable even in so short a chapter to refer also to flavins other than riboflavin and to flavoproteins additional to the 'old' yellow enzyme of Warburg which is now of little more than historic interest.

The value of the extensive bibliography is greatly enhanced by the inclusion of titles of the papers, a convention which could with advantage be made more general.

E. F. Hartree

ISOTOPIC METHODS IN BIOCHEMISTRY

Isotopic Tracers in Biochemistry and Physiology
By Prof. Jacob Sacks. Pp. vii + 383. (London: McGraw-Hill Publishing Company, Ltd., 1953.) 68*s*.

As isotopic methods have become increasingly used in biochemical research, so the number of text-books concerned with the applications of isotopes has also increased. This recent addition to the collection discusses the principles underlying the design of tracer experiments and describes many of the results that have been obtained by the application of isotopic methods.

The first six chapters will appeal to many students of this subject as giving a lucid account, with the minimum of mathematical treatment, of the fundamental principles of nuclear physics and the general methods involved in the use and measurement of both radioactive and stable isotopes. The author is throughout concerned to stress that the use of this new technique introduces its own peculiar errors, and that tracer experiments have to be carefully designed, and, possibly more important, that the results have to be very carefully interpreted. *O sic omnes!* Some topics may seem to have been dealt with all too briefly, and there are a few statements which could lead the poorly informed reader to erroneous conclusions, for example, the statement that "the efficiency of Geiger–Müller counters for beta particles is practically 100 per cent". These criticisms are in part met by the references to other books which are given at the end of each chapter, though the reviewer has been struck by the trans-Atlantic nature of these general references. Without exception they are references to American-published books, and almost without exception the authors are themselves American investigators.

The second and major part of the book, consisting of ten chapters, leaves one much more doubtful as to its general usefulness. These chapters, which are almost entirely biochemical, describe the experimental results which have been obtained in the main fields of biological research using isotopic tracer methods. There is a great deal of information here and it must have cost the author much energy to collect it; but if the purpose of this section is to show by selected examples how tracers have been applied in particular cases and how the results have been interpreted, then all the material presented here is not necessary. Furthermore, since the material is divided into chapters dealing with carbohydrate metabolism, protein metabolism, lipid metabolism, etc., there is a tendency to assume that one is being given a complete account of the development of the field, though of course no mention is made of the not inconsiderable advances which have been made in biochemical knowledge without the use of

isotopes. In addition, the work described here is again drawn almost entirely from American sources, and one is in fact being given an account of the main contributions by American biochemists and physiologists which have involved isotopic methods. This may be justified in a history of American biology; but one doubts its necessity in this particular book. Nevertheless, the material presented is described with masterly clarity, and if its limitations are realized, is well worth reading for its own sake. It should also be said, in all fairness, that two of the chapters in this second section of the book, namely, Chapter 7 on the movement of ions across boundaries and Chapter 16 on photosynthesis, are exempted from some of the criticisms given above, since in these subjects the major advances have been made only since the availability of tracer methods.

Prof. Sacks has written a book which is in many ways a useful addition to the literature of what his countrymen like to call 'tracerology'; but one cannot help feeling that his contribution would have been more generally useful and welcome if the first six chapters had been extended to, say, twelve chapters at the expense of the remaining ten.

The book as a whole seems to be remarkably free from errors and misprints, and the publishers are to be congratulated on the quality of the printing, paper and binding. WILLIAM C. HUTCHISON

THE PSYCHOLOGY OF PERSONALITY

The Structure of Human Personality

By H. J. Eysenck. (Methuen's Manuals of Modern Psychology.) Pp. xix+348. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1953.) 37*s*. 6*d*. net.

DR. EYSENCK of the Maudsley Hospital, London, is already well known for two major contributions to the literature of personality, "Dimensions of Personality" (1947) and "The Scientific Study of Personality" (1952). Although these books owed much, and contained numerous references, to the work of others, they were primarily concerned with giving an account of the investigations carried out by Eysenck and his associates. The present book, on the other hand, is a systematic and critical account of the field as a whole in which Eysenck's own work and its conclusions, though of course they colour his general treatment, are explicitly mentioned only in their appropriate contexts. It is, therefore, the complement of its two predecessors. Taken together the three books are a vigorous and important, if controversial, contribution to contemporary psychology.

Since the publication of Allport's "Personality" (1937) there has been a growing recognition that personality is perhaps the most appropriate integrating concept in psychology. It is defined by Eysenck in the present book as "the more or less stable and enduring organization of a person's character, temperament, intellect and physique, which determines his unique adjustment to the environment" (p. 2). The concept of personality is not only of importance in psychiatry and in most of the applied fields of psychology, but also, as recent work has shown, in many laboratory investigations into apparently quite narrowly specific topics. There is much less agreement, however, as to how this highly complex organization is to be studied. In the controversies which centre around this issue Eysenck is a protagonist. There are no half-measures about his point of view; he is wholly with those who believe in an analytical, mathematical and formally correct scientific approach; he is wholly against all that is untestable, qualitative, verbal, and 'holistic'. He believes not only that personality ought to be studied by the same objective methods as are used in the physical sciences, but also that it can now effectively be so studied. He looks ultimately for "the construction of a mathematical model of personality organization, and the derivation of testable hypotheses from this model by means of the hypothetico-deductive method" (p. 322).

In its approach to this ideal Eysenck's work stems chiefly from the 'London school', of which the main theoretical framework, deriving from Sully, McDougall and Burt, is that of hierarchical structure, and the principal technique, deriving from the psychometric investigations of Galton, Pearson, Spearman and others, that of factor analysis. The present work is indeed entirely devoted to a survey of the numerous factor analytic studies of personality which have been carried out mainly in Great Britain and America. No other line of work receives any serious mention, not because Eysenck is unaware of the existence of this work, but because he believes it to be of small value until factor analysis has established the basic dimensions, or taxonomy, of personality. Within the strict limits imposed by its author's point of view there can be no doubt that "The Structure of Personality" is an important book. It is not only valuable as a work of reference to many tedious investigations, it also contains a good deal of critical comment, to which all those who propose to employ factor analysis must seriously attend. For one thing at least is certain: if factorial methods are to be used at all, they must be used proficiently. Eysenck's insistence on high standards of technical competence is wholly praiseworthy.

The main doubts concern the foundations of the enterprise, and these unfortunately Eysenck does little to remove. The results which factor analysis has so far yielded in the field of personality are not sufficiently compelling to remove these doubts and to command general acceptance. These doubts not only concern the adequacy of the tests and assessments upon which the elaborate statistical structure of factor analysis is erected, but more fundamentally the adequacy of the theory of traits to serve as the firm basis of an exact science. This theory bears a suspicious resemblance to the ancient doctrine of primary qualities which so long impeded the development of the physical sciences, and it may be more than a coincidence that modern typologies, including that favoured by Eysenck, so closely resemble the classical theory of temperaments which was directly derived from that ancient doctrine. If, as is not improbable, the theory of traits is a completely false road in the study of personality, the whole factorial edifice which Eysenck and others have erected collapses. Eysenck in his enthusiasm for scientific methodology appears to forget that no methodological finesse can avail unless the right questions are being asked; and to ask the right questions often requires, as Butterfield put it in his "Origins of Modern Science" (1949), "a different kind of thinking-cap". Gardner Murphy in his "Personality" (1947) was perhaps aware of this when he wrote, "Neither in content, nor in method can we be said to have solved the essential problem

of the starting point from which a psychology—any kind of psychology, including a psychology of personality—could be written. . . . We shall rectify mistakes not primarily by the minor readjustments of the lines of the argument, but by recognition of the fundamental limitations of the whole present system of conceptions". Perhaps Eysenck would not wholly disagree with a statement such as this, for he more than once implies that factorial studies are provisional only, until more solid methods are available to take their place. Whether even as a provisional method their value is as great as Eysenck believes, or whether other less precise methods deserve the total rejection which Eysenck accords them, time will no doubt show.

L. S. Hearnshaw

THE PSYCHOLOGY OF SPECTRES

Apparitions

By G. N. M. Tyrrell. Revised edition. Pp. 172. (London: Gerald Duckworth and Co., Ltd., 1953.) 12*s*. 6*d*.

THIS book, the first edition of which was reviewed in *Nature* in July 1943, is a revised version of the seventh Frederic W. H. Myers Memorial Lecture which was delivered by Mr. Tyrrell in October 1942. Since that date the theory that Mr. Tyrrell then put forward has met with a growing interest, and in the present volume Prof. H. H. Price, in an admirable introduction, gives it as his opinion that the book is probably the best of all the late Mr. Tyrrell's contributions to psychical research.

Dismissing the physical theories of apparitions as almost wholly unpromising, Mr. Tyrrell turns to those of a psychological nature. To him, apparitions are hallucinations of a particular and very interesting kind, and he divides them into four main classes which, however, cannot be very sharply differentiated. These four classes are: (1) Experimental cases, in which the agent tries to make an apparition visible to a particular percipient. (2) Cases in which a recognized apparition is seen, heard or felt at a time when the person represented by the apparition is undergoing some crisis such as a moment of danger or even death. (3) Cases in which a recognized apparition is seen or heard so long after death or after some crisis that no coincidence can be supposed. (4) Cases of alleged haunted localities in which apparitions are said occasionally to be observed. Cutting across these cases there are a number of characteristics which are common in a greater or lesser degree to all four classes. Moreover, these characteristics, which are of constant occurrence in the statements of the various witnesses, suggest that, in the majority of cases, the accounts are not merely the inventions of imaginative persons, but that they describe actual incidents which have occurred within the experience of the percipients.

One of the main features of Mr. Tyrrell's theory is what he terms the 'idea-pattern', which is the dramatic production of the agent's idea, the apparition itself being the sensory expression of the idea-pattern. It is in no sense a substantival entity but rather the creative product of substantival constituents belonging to one or more personalities. Thus what is perceived as a full-blown hallucination is merely the outward expression of a drama; and it is within this drama that elements can be detected which may be able to throw considerable light upon the deeper strata of human personality and the remarkable power of subconscious activity.

In developing his thesis Mr. Tyrrell is careful to avoid any extravagant suggestions. He relies for his facts upon the best cases to be found in the literature, especially those published in "Phantasms of the Living" and in the *Journal* and *Proceedings of the Society for Psychical Research*. How far these accounts can be relied upon is for the reader himself to decide. More than sixty years ago Mr. A. T. Innes, in a discussion of "Phantasms of the Living" (1886), pointed out that contemporary letters and documents proving the authenticity of the crisis cases were conspicuous by their absence, and he went so far as to state that of seven hundred miscellaneous cases which he had examined *one* only was accompanied by a relevant document.

Although perhaps it might have been wiser in this edition to warn the reader regarding the weakness of many of the examples quoted and to have recorded the gist of the Innes–Peirce–Gurney controversies, the book remains the best critical discussion of apparitions that has hitherto appeared. It sweeps away many of the misconceptions so common when discussing 'ghosts', and brings the whole subject into sober perspective so that these very curious phenomena can be fitted (at least partially) into the psychological framework where they undoubtedly belong.

E. J. Dingwall

LOGIC FOR MODERN SCIENCE

The Logic of Modern Science

By Prof. J. R. Kantor. Pp. xvi+360. (Bloomington, Indiana: The Principia Press, Inc., 1953.) 6 dollars.

THE principal thesis of this book appears to be that scientific procedures and results have been too much and too unwittingly influenced by cultural institutions. The author, who is a psychologist, therefore proposes to reject all current ontological, epistemological and psychological theories concerning natural science, for these all suffer from the defect of involving what the author calls mentalistic and spiritistic notions which have been introduced not in the interest of science but of theology. But he goes even further than this: he not only rejects Berkeley but also Hume. He wishes, apparently, to reinstate naïve realism in epistemology and to retain a thing-attribute theory in ontology. His psychological theory is his own and is called interbehaviourism to distinguish it from ordinary behaviourism which he rejects. He calls the latter "the end point in the dualistic development we have just sketched". The psychological organism becomes the *body without mind*. The behaviourists, for example, simply deny the necessity of dealing with any psychic factor. The strict behaviourist attempts to interpret all psychic happenings in terms of the operation of the brain and other nervous structures.

"But has the behaviorist disposed of 'mind'? Hardly. He simply throws away one half of the traditional body-mind construction and builds his system on the remainder. In no sense does he extricate himself from the dualistic tradition. What is required is to withdraw completely from historical constructions. We need to start over again. *Interbehavioral* psychology . . . makes this attempt" (p. 259).

The present reviewer confesses that he has failed to understand interbehavioural psychology from what the author says in this book. Perhaps it is necessary to read the same author's other books on the subject. The most easily understood parts of the present work are naturally the critical parts. These have much that is interesting to say about physics, chemistry, biology, psychology and sociology. After such wholesale destruction anything constructive is bound to be so novel and revolutionary as to be extremely difficult to follow. This difficulty is increased in the present instance by the author's rather loose use of language and the absence of detailed argument showing how the new view overcomes the difficulties with which the older theories attempted to deal.

The word 'logic' is used throughout in a very wide sense, and the few remarks which the author makes about logic in the narrower and stricter sense are rather misleading. Consequently, when the author comes to discuss such questions as: "What is the significance of abstract formal systems for scientific work?" and: "Are scientific laws deduced from the premises of logical systems or constructed from events?" his treatment of these topics (which require a knowledge of logic in the narrower sense) is intuitive and popular rather than analytical and scientific. No mention is made in the extensive bibliography of the work of Carnap, Church, Quine or Tarski among the many who have contributed to these topics in recent years. Similarly, the chapter on mathematics and natural science, which makes no reference to the work of Frege, Whitehead and Russell, Hilbert or Brouwer, scarcely rises above the popular level and gives a very misleading notion of the present state of knowledge.

J. H. Woodger

VERMUYDEN AND THE FENS

Vermuyden and the Fens
A Study of Sir Cornelius Vermuyden and the Great Level. By L. E. Harris. Pp. 168+8 plates. (London: Cleaver-Hume Press, Ltd., 1953.) 21*s.* net.

THE draining of the Fenland is one of the most notable enterprises in the history of the English countryside. It was achieved only with much difficulty, and the main architect of that achievement was Cornelius Vermuyden. He was born in 1590 on the island of Tholen in Holland, and moved to England in 1621. He was involved in a number of enterprises; but the greatest, and the one upon which his reputation must rest, was the draining of the great stretch of peat later known as the Bedford Level.

During the latter years of the sixteenth and the early years of the seventeenth century, the possibility of draining this area was hotly debated, and the debate culminated in 1630 in a project headed by Francis, fourth Earl of Bedford. Vermuyden was already interested in the scheme, and, at the request of the Earl, he undertook the direction of the work. Discussion had ranged around two opinions. One held that the existing watercourses should be deepened and embanked; the other, held by Vermuyden, advocated that new and artificial straight cuts be made. So it was in accordance with this second view that the work proceeded. The confusion of the Civil War, and continued hostility to the scheme, interrupted the progress of the work, and it was not until 1652 that the area was formally declared to be drained. Vermuyden's connexion with the Level appears to have ceased in 1655; and but little is known of his life after this. The date of his death was in doubt, but Mr. Harris has now shown that it was 1677; the record of the burial is in the register of the Church of St. Margaret, Westminster.

The work of Vermuyden, both while it was in progress and afterwards, was surrounded by controversy, and it is true that successive floods, more than once, very nearly brought the scheme to disaster. As one engineer, John Golborne, wrote in 1777: "Look which way you will, you will see nothing but misery and desolation". Neither Vermuyden nor his associates apparently had realized that as soon as the peat was drained, its surface would become lower, and that pumping would be necessary. It is this lowering that has very largely been responsible for the continued flooding of the Fens. Successive engineers bitterly attacked Vermuyden's engineering works on technical grounds, and Mr. Harris guides us with great skill through the many differences of opinion. Moreover, he points out that "the only practical standard of comparison to apply to Vermuyden's work is how the drainage of the Great Level would be carried out to-day, assuming that conditions in, and the state of, the Level were as they existed in the mid-seventeenth century. Would a similar plan be adopted?" It is a difficult question to answer; but the fact is that the new Flood Relief Scheme embodies features that Vermuyden proposed but which were never carried out. Had these been carried out, "his scheme would have proved even more successful than in fact it did". The general professional verdict on Vermuyden's work has "become more favourable", and something of his greatness appreciated.

Amid this story, some light is shed upon Vermuyden himself. He was "a hard man of business", both "dominating and aggressive", certainly litigious. "It is debatable whether Vermuyden could be considered to have been a likeable man." But in making these remarks, Mr. Harris would have us remember that the bitter criticism of his work was certainly unjustified, and that there is no "valid reason why the judgement of success should be withheld from him".

This book not only throws light upon a little-known figure of the seventeenth century, but also is of the first importance to any student of fen draining. It most skilfully handles difficult material, and presents a balanced picture of a man and a problem. It is also attractively written and attractively produced and illustrated. H. C. Darby

ORIGIN OF METAMORPHIC ROCKS

The Origin of Metamorphic and Metasomatic Rocks
A Treatise on Recrystallization and Replacement in the Earth's Crust. By Prof. Hans Ramberg. Pp. xvii+317. (Chicago: University of Chicago Press; London: Cambridge University Press, 1952.) 75*s.* net.

THIS interesting book is the latest of several texts, dealing with the origin and formation of crystalline rocks, that have appeared in recent years in the United States. Prof. Ramberg confines himself to the field of metamorphism, though this is viewed

in the broadest terms so that such operations as granitization are included. The sub-title indicates the author's respect for metasomatism as a rock-forming process, a subject with which the last third of the book is largely concerned.

In his opening discussion of some of the principles of thermodynamics and crystal chemistry, Prof. Ramberg bases his analysis of chemical processes in rocks on the concept of free energy. He argues that this is simpler than a discussion of the relations of minerals with a hypothetical pore fluid. He makes a most interesting attempt to compile equilibrium diagrams for metamorphic minerals largely from the data provided by mineral assemblages in the different metamorphic facies. It is considered that such diagrams, even though calculated theoretically from an insufficient number of points, provide the best way we have of presenting the scanty data available on the behaviour of metamorphic minerals under changing pressure–temperature concentration conditions. The tentative nature of these diagrams is repeatedly pointed out and, provided this is borne in mind, a very promising method of dealing with metamorphic assemblages seems to be developed. An appendix on chemical bonds in crystals is provided as a supplement to these early chapters.

A discussion of the kinetics of metamorphism leads on to the more strictly petrological parts of this book. These make up about two-thirds of the text, and may well, as the author points out, be read first. Here emphasis is put upon the general principles of petrogenesis, while the "collection of erratic data and descriptions of rocks or field relations are kept at a minimum". This quite justifiable treatment requires that the reader must have a general acquaintance with metamorphic rocks. Such a treatment does not mean that field evidence is neglected. On the contrary, one of the most attractive features of the work is the attention paid to what might be called the architecture of the extensive regionally metamorphosed terranes. This is shown in the survey of structural properties of metamorphic rocks and again when the deep-seated quartzo-feldspathic rocks are described during the discussion of metasomatism. These sections are illustrated by excellent photographs, most of which were taken by the author during his work in Greenland.

After a short discussion of stress and antistress minerals and the structural survey mentioned already, there comes an account of the mineral facies of metamorphic rocks, with emphasis on the assemblages formed during regional metamorphism (twenty-seven pages) as against those formed during contact metamorphism (two pages). This emphasis is maintained in the treatment of metasomatism and metamorphic differentiation and is no doubt deliberate, for the author is concerned to show the prime importance of regional metamorphism and metasomatism as rock-forming operations.

Metasomatism is recognized as a complex and little understood process. If we accept the author's view that this process is not one in which we can "expect to receive aid from physics and chemistry in the form of laws ready to be applied to our complex problem without many modifications", the lengthy discussion of transfer of matter through rocks must at times seem rather speculative. But unless geologists with the experience of Prof. Ramberg are prepared to expose their views on the subject, we may never get to grips with the question. This discussion is followed by an account of metamorphic differentiation, after which there is the briefest of references to contact metasomatism (twenty lines) and a very relevant excursion into metasomatism in practically unmetamorphosed sediments. It is a pity that these last two topics could not have been treated more fully, for an understanding of such matters would contribute to our comprehension of the regionally metamorphosed schists and quartzo-feldspathic gneisses which constitute the major problem. Whether or not one agrees that such rocks are the product of diffusion through the solid, the author must be given credit for setting out so clearly the facts about the occurrence of such rocks in the deeply eroded mountain chains, facts which any hypothesis on deep-seated plutonism must take into account.

H. H. Read

GENETIC CLASSIFICATION IN MINERALOGY

Spezielle Mineralogie auf geochemischer Grundlage Mit einem Anhang: Ein kristallchemisches Mineralsystem. Von Prof. Felix Machatschki. Pp. vii + 378. (Wien: Springer-Verlag, 1953.) 61*s.* 6*d.*

ALMOST all text-books on mineralogy have been based on a chemical classification more or less modified by structural considerations; the first subdivision has been into elements, sulphides, oxides, carbonates, silicates, etc., while within each of these divisions the big isomorphous groups of species, such as the rhombohedral carbonates, the feldspars, or the spinels, form natural units. More recently, the developments of structural crystallography have allowed an intermediate division by structurally allied groups such as the island, chain, sheet, and network silicates.

Prof. Machatschki has experimented with a quite distinct method of classification—a genetic one. Followed strictly, this approach would lead to the dispersal of many familiar groups of structurally and chemically allied species such as the pyroxenes; this and other considerations have deterred him from following his idea to its logical conclusion, and some readers may feel that this division of aim detracts from the unity of the book. But all should find the novel approach stimulating, and the book should prove a very valuable addition to the bookshelf of mineralogists and petrologists alike. It is difficult to decide at a first reading how far the divided aim will prove of serious detriment; but of the value of many features of the book there can be no doubt.

After a short introduction Prof. Machatschki deals with the primary magmatic minerals in order of crystallization, then with pegmatitic-pneumatolytic, hydrothermal, and solfataric minerals. The second section deals with clays, lateritic minerals, and other weathering products, evaporites, and minerals of organic origin, and the third with the minerals of metamorphic rocks. A great many minerals would fall into more than one of these headings and many familiar mineral families would be scattered over several headings; so each well-known family is discussed in detail at the earliest point in this genetic development where any member of the family is encountered. The ore minerals are treated exceptionally; instead of being dealt with as they are met in the logical genetic series, their detailed descriptions are all collected in a special section, arranged

under metals, with particular attention to the rarer metals. A rather similar and very useful arrangement is adopted for the pegmatitic-pneumatolytic minerals, which are divided into lithium, rubidium–cæsium, beryllium, boron, etc., minerals.

As an appendix, a strictly crystallochemical classification is attempted, which may be of value in disclosing some unexpected structural similarities.

The chemical formulæ for the species are a feature to which Prof. Machatschki has given special attention. He indicates the co-ordination of the principal atoms or groups by bracketed superscript numbers (for example, $Si^{[4]}$, $Al^{[6]}$), and encloses polyatomic anions with homopolar or largely homopolar links in square brackets (for example, $[SO_4]$, $[(Si,Al)O_3]$); structures based on homopolar-linked chains, sheets, or networks are prefixed ∞^1, ∞^2, and ∞^3 respectively, while the chemical formula is followed by a letter or pair of letters symbolizing the system of crystallization. These features should prove very useful in giving a condensed picture of the principal structural features.

There are few errors or omissions of consequence, though some rare minerals are unexpectedly included and more common ones omitted (for example, the very rare edingtonite is included, and incorrectly stated to be related to scolecite, while the much commoner mordenite is omitted; and mesolite is a definite compound, not a mixed-crystal).

M. H. Hey

CLAY MINERALS

Clay Mineralogy

By Prof. Ralph E. Grim. (McGraw-Hill Series in Geology.) Pp. xii+384. (London: McGraw-Hill Publishing Company, 1953.) 64*s*. 6*d*.

THE extent of the interest in clay minerals is very wide, as Prof. Grim points out in the introduction to his excellent book, ranging as it does from the earliest of human industries—pottery making and agriculture—down to the cracking of oils in modern refineries. Physical and physiochemical studies carried out by many workers over the past hundred years had provided a considerable insight into the properties of clays; but it was not until Hadding's discovery of their crystallinity that a more fundamental attack on the subject was possible. The adumbration by Goldschmidt and Pauling of the laws of crystal chemistry and their application by C. E. Marshall to minerals like montmorillonite made further advances possible. While much has been learned about clay minerals in the relatively pure state, much remains to be done on the complex mixtures that occur in such materials as soils and sediments. The quantitative aspects of such mixtures still bristle with difficulties that will not easily be overcome.

As in other aspects of mineralogy, misidentification and duplication of names has proved troublesome; but in his discussion of this Prof. Grim surely goes too far in relegating beidellite to the ranks of discredited species. Attapulgite would be a more appropriate candidate, for all the evidence points to the identity of this and palygorskite, which has a very long-standing priority. Recent work has certainly shown the advisability of checking all identifications by X-rays, otherwise much work can be completely vitiated.

Appropriately, the main part of the book begins with a good account of the structures of the various clay minerals, with tabulated data taken largely from the Clay Mineral Group's monograph. The latter will, however, still be essential to anyone wishing to use X-ray techniques, for in a general text it is obviously impossible to cover every aspect of the work and discuss the many difficulties that arise in the interpretation of X-ray diffraction patterns of clay materials.

Successive chapters then deal with electron micrograph studies on shape and size, and with ion exchange. In this last Prof. Grim seems out of his element, but it is an adequate account. In marked contrast are the chapters on the clay–water system and the effect of heating on clays, in which the author is dealing with aspects to which he has contributed much, and both are very thoroughly treated. Reactions with organic substances, which come next, have proved extremely valuable both in connexion with the properties of the clay minerals and their identification, but also in opening up the possibility of studying the organic molecules taking part. This has obvious bearings on the reactions between soil organic matter and clays and in particular the apparent inactivation of certain types of substances with regard to biological decomposition. Chapters on the optical properties of clay minerals and miscellaneous properties (solubility, infra-red spectra, etc.) complete what one might call the laboratory side. In the last two chapters Prof. Grim deals very thoroughly with the origin and formation of clay minerals as far as the data will allow. Many more field data are required before one can obtain a clear picture of clay mineral formation in many cases. One would have hoped that something like an 'inverse' Bowen reaction series might have held good for the natural synthesis of clay minerals, but there seem to be too many exceptions.

In a book covering such a broad field it would be easy to find fault on particular points, especially since the subject is developing so rapidly. The book is well documented both in footnotes and supplementary bibliographies in each chapter, and it can be thoroughly recommended.

A. Muir

GEOLOGY AND SCENERY

Geology and Scenery in Britain

By T. G. Miller. Pp. 224+31 plates. (London: B. T. Batsford, Ltd., 1953.) 18*s*. net.

IN writing a work dealing with the correlation between the geological make-up and scenery of Britain, the author has chosen to enter a highly competitive field of geological literature. Personally, I doubt the need for any further addition to it, unless the aim is to go beyond and into the dependence upon the outward expression of the rocky skeleton of the country of the organic population and its manifold activities. Were such a subject the main theme of this book, it might well claim some novelty, and indeed in the introduction we are promised more of this than eventually materializes. The author sets out to produce a compromise between the 'country book' and the technical regional survey, the whole to be comprehensible to the layman with a love of the countryside. The balance is far from lying midway between the two and in fact lies heavily towards the

regional survey, in which case it becomes justifiable to compare it with similar productions. It also appears that Britain comprises England and Wales only, so that the scope of the book becomes identical with Sir Arthur Trueman's "Geology and Scenery in England and Wales". Since the latter is available for half-a-crown, Mr. Miller sets himself a task of no inconsiderable magnitude in crashing into the market.

On the whole he has produced a readable volume and in places displays astonishing lucidity. What is said is said in a concise manner, and most geologists would appreciate the deftness with which the author disposes of masses of detail; but I think that the layman would appreciate a sacrifice of some of the subject-matter and a fuller, if more cumbersome, exposition of a well-selected residuum. Mr. Miller has used this technique in his useful diagrams. Why not in the text? The pithiness of certain sections of the early chapters dealing with the fundamental principles of geological science is admirable, but there is a tendency for certain short asides and summaries to miss the point in an irritating manner. This phenomenon of just missing the target applies also to some of the quotations used as chapter headings. Thus I do not think that the conflict between Man and Nature can be summed up as "dubious neutrality" (p. 22) on the part of the former, or that a quotation involving "the mountains far away" (p. 73) is an appropriate introduction to a chapter on the older rocks of Wales. Bacon's conception of the earth (p. 19) does not harmonize with the geologist's approach and stands in marked contrast to the subject-matter of the chapter which it introduces. If quotations are not apt they ought not to be used.

The volume includes some very fine plates illustrating scenery and structures. One might protest against foreign views being included in a work on British scenery were it not for the fact that they are among the best in the book. The Persian photographs especially are wonderful. The references to Plate 30 on page 76 and to Plate 31 on page 81 should be interchanged.

The author has produced a painstaking review of his subject; he can write well and I am glad to have his work on my shelves. Even so, if one is limited to a single volume on this topic, there are better works already available. FRANK HODSON

THE EARLY DAYS OF AGRICULTURE

Plough and Pasture

The Early History of Farming. Part 1: Prehistoric Farming of Europe and the Near East. By E. Cecil Curwen. Part 2: Farming of Non-European Peoples. By Gudmund Hatt. Pp. xii+329+14 plates. (New York: Henry Schuman, Inc., 1953.) 5 dollars.

AGRICULTURE has been practised for some six or seven thousand years; but its written records go back for only about one-third of this time. Fortunately, modern archæologists have been able to unravel a great deal of the earlier history and it is now possible to draw up a much more extensive account than was practicable a generation ago.

Mr. Curwen and Prof. Hatt have summarized much of this new knowledge, but instead of writing one book jointly Mr. Curwen has in one section described the prehistoric farming of Europe and the Near East, while in the other section Prof. Hatt deals with the farming of non-European countries.

Mr. Curwen, who is already well known for his writings on Sussex archæology, starts with the primitive food-gathering stage of human history, and shows how the gradual drying of the climate in the eastern Mediterranean and Near East curtailed the range of operations. Mankind then split into two groups. One tended to settle in the river valleys and well-watered oases where its members cultivated some of the wild grasses; the other group remained nomadic but could no longer rely on hunting and food gathering; instead they domesticated certain animals and became pastoralists, wandering from one set of grazing lands to another, at first indiscriminately, but later kept to a regular sequence of dry and wet season pastures, each tribe having its own particular lands. Gradually the settled agriculturists developed the arts of civilization, the sciences and the practical activities: they became inventors, traders and ultimately industrialists; the pastoral peoples on the other hand tended to become more contemplative and developed religions, poetry and the mystical arts. Mr. Curwen shows how the ancient traditions of Egypt, Greece, and Palestine as expressed in the Old Testament agree in placing the origin of this dichotomy of races in an area bounded on the west by the river Nile, on the east by the river Indus, and on the north by about the forty-fifth parallel. The period in time was the end of the Mesolithic and the beginning of the Neolithic age.

The early history of the cultivated cereals, the domesticated animals and the implements is given in some detail; the account of the plough, however, should be read in conjunction with F. G. Payne's studies on this subject. It is remarkable that the number of kinds of plants and animals used as food has decreased since the early food-gathering days and that very few additions have been made to the list of common foods with the exception of migrants such as potatoes and maize, which, however, had been used from very early times in their respective countries of origin.

English readers will welcome the opportunity of reading the account by Prof. Gudmund Hatt, of the University of Copenhagen, of the development of agriculture in countries outside Europe and the Middle East. He begins with accounts of food gathering in the Americas, Australia and Africa, and describes some of the protective magic associated with it. The "symbiosis between man and plants" and the "religious fear of wronging the food plant", to quote the author's phrases, gradually developed into agriculture which doubtless originated independently in the different continents, for the human migrations had taken place long before it occurred. The earliest stage was a combination of hunting by the men and a rudimentary agriculture practised by the women using digging sticks. This semi-agriculture gradually developed into full agriculture using implements drawn by animals directed by men. Roots—yams, cassava and others—played a larger part than in Europe; maize seems to have come late into North America. The Kentucky caves give evidence of the cultivation of sunflowers, goosefoot (*Chenopodium*), a pumpkin (*Cucurbita pepo*) and a gourd (*Lagenaria siceraria*) long before pottery was known or maize or

beans grown: curiously enough the gourd seems to have been of Old World origin. Tobacco culture was widespread in America even among tribes that did not grow food. It is unknown whence or how maize came into cultivation, but its arrival was a turning point in American history, for it made possible the magnificent cultural evolution in the Andes and in Central America, Mexico and the south-west area. Wherever it came from, Colombia appears to be its oldest centre of cultivation. Colombia also appears as the centre of origin of a number of other cultivated plants.

The book contains a large amount of information that will be new to many readers and which, moreover, is not generally accessible. It can be commended to all who are interested in the origins and early history of our domesticated animals and field crops, and in the tools men used for dealing with them.

E. JOHN RUSSELL

THE SOILS OF EUROPE

The Soils of Europe
Illustrated Diagnosis and Systematics. By Prof. Dr. Walter L. Kubiëna. Pp. 318+26 plates. (Madrid: Consejo Superior de Investigaciones Cientificas; London: Thomas Murby and Co., 1953.) n.p.

UNTIL the identity of a creature can be established and communicated, correlation and the transfer of experience are impossible and knowledge remains chaotic. The recognition and precise description of kinds of plants and animals by such men as Turner and Gesner in the sixteenth century provided the essential foundation for modern biological science; and as a pedologist Dr. Kubiëna is surely right in asserting the urgency of his aim in this book, which "is an attempt to make it possible to identify and to give suitable names to soils for all who need it". Descriptions of 173 different "formations of soils" are illustrated by more than fifty excellent reproductions of beautifully executed paintings chosen in preference to photographs to emphasize the features regarded as most significant. Keys are provided to facilitate rapid identifications which may then be checked by the more-or-less detailed profile descriptions. Many synonyms are carefully equated in the explanation of more than four hundred soil names and some two hundred pedological terms. Dr. Kubiëna claims to have studied personally most of the soils described, and it may well be doubted if any other person could provide such an extensive background of personal experience. It is a pity that in this translation from the German such a valuable book should be marred by English so often ambiguous that the reader is left doubting those subtleties which may well have been intended; and from the number of typographic errors it seems doubtful whether the proofs could ever have been read at all.

The development of a precise terminology, a clear and concise nomenclature, and an orderly and serviceable classification are probably the three most urgent requirements in the study of the soil. In the field of profile description Dr. Kubiëna is particularly helpful in those features of the profile which reveal themselves best under the microscope. His account of both the morphology and genesis of the various forms of organic matter establishes without question the value of his techniques, while the features upon which he bases his important distinction between *Lehm* and *Erde* could scarcely be fully discerned by the unaided senses. Many of the profile descriptions, however, are quite inadequate for precise diagnosis, and some of the more obvious features, such as major profile structures, for example, are often not described at all.

In nomenclature, Dr. Kubiëna adopts a Linnæan approach, and perhaps assumes too readily that the success of a system for plants and animals is a guarantee of its value in soils. Indeed, in his assumption that soils may be "as exactly and unambiguously characterized and named as breeds of cereals, market garden crops, and domestic animals" Dr. Kubiëna is assuming an analogy which is misleading. Plants and animals are discrete and transferable units with their essential characters determined by an internal mechanism, whereas soils, as Dockuchaiev insisted, "are a mere function of the soil-forming factors". As in petrology, the essential problem is the significant division of a gradually varying continuum, and it may be that a premature enthusiasm for "pigeon-holing" may divert energies from the more vital study of soil and landscape relationships. That Dr. Kubiëna is himself aware of the merging of soil boundaries is clear from his emphasis on the strongly dynamic nature of soil profiles; and his evolutionary division between raw soils, ranker soils, and more mature soils recognizes, at a high level in his classification, profile development sequences similar to those which have been shown to be of such practical value in New Zealand. To arrange soils in order from the simplest to the most complex, after consideration of "all essential characteristics", is a logical aim, but its adequate fulfilment will require much more knowledge of profile dynamics than we now possess.

The book is stimulating and of lasting value, and cannot be neglected by any serious student of the soil.

E. CROMPTON

ELECTRONIC THEORY OF VALENCY IN ORGANIC CHEMISTRY

Electron Structures of Organic Molecules
By Prof. Lloyd N. Ferguson. Pp. xi+335. (London: Constable and Co., Ltd., 1952.) 48*s*. net.

THE scope of this book is correctly described in its title. As is explained in the introductory chapter, it gives an up-to-date account of that part of physical organic chemistry which is concerned with molecules in their normal (non-reacting) states. Successive chapters carry the following headings: the types of chemical bonds, the polar nature of covalent bonds, covalent bond distances and bond angles, intramolecular forces, induction and electric dipole moments, magnetic susceptibility, resonance and its applications in organic chemistry, absorption spectroscopy (this chapter and the preceding one occupy almost half the book), aromatic substitution, and molecular and electron structures by physical methods.

The treatment is clear and the expositions generally full, so that the book is interesting to read and should be easily followed by the honours degree student for whom it seems to have been designed. Yet a conscientious teacher might hesitate before recommending the book without qualification—especially as it is so expensive.

Misprints occur in all books, and in this one not oftener than the average; but the erroneous formula for picryl iodide on p. 174 and the mistake in equation (8) on p. 220 are examples of rather serious slips. What is much more serious is that the writing abounds in loose phraseology such as, "the four valencies of a carbon atom form a tetrahedron" (p. 89), or the "equation ($A = A^{+}_{sol.} + e^{-}$) is the electrode potential" (p. 70). Again, to write of associated compounds on p. 65 that the "association increases the solubility in water" is surely to suggest a false causality. In a single paragraph on p. 60 the phrase "degree of association" is used in two distinctly different senses. Furthermore there are some misleading statements: "the chief use (of X-rays) to organic chemists has been with crystalline powders" (p. 82), and "electron diffraction is the principal type of diffraction studies being made now" (p. 83) are opinions that could not long survive a glance at any recent volume of the "Structure Reports". In several places (for example, pp. 22, 144, 159) the inexpert reader will gain the impression that the molecular orbital treatment is merely a part of the resonance concept, instead of being an alternative and independent method of approximation.

When another American author has written of "the electronic theory of the English school", it is surprising to find the names of Ingold, Lapworth, Robinson and Sidgwick together accounting for only 14 entries in Prof. Ferguson's author-index, while several Californian or mid-Western authorities individually exceed this total. (On the other hand, two well-known American workers appear as "R. B. Core" and "J. Donahue" in both text and index.)

Most of these defects are superficial and could be easily remedied, and to have pointed them out at this length is to have emphasized them unduly unless it is also emphasized that this book has many virtues. A large quantity of current information is brought together in a useful way, and offered in a readable form. Those able to read the book with judgment will find it valuable. After every few pages there is a list of books and review articles for supplementary reading. These lists are up to date and well chosen; and they are by no means confined to American publications. With due safeguards, this book should be made accessible to advanced students of chemistry; it can be recommended to any of their seniors who may be concerned with physical organic chemistry.

J. C. Speakman

CATIONIC POLYMERIZATION

Cationic Polymerisation and Related Complexes

Edited by Dr. P. H. Plesch. (Proceedings of a Conference held at the University College of North Staffordshire, 24th–26th March, 1952.) Pp. xii+166. (Cambridge: W. Heffer and Sons, Ltd., 1953.) 20*s*.

THE experimental investigation of cationic polymerization was initiated in the early 1930's, as Dr. Plesch points out in his most admirable preface to this book, when it was recognized as a distinct type of polymerization reaction by reason of the fact that it could not be fitted into the general theory of free-radical chain reactions. Since that time, spectacular advances have been made in the understanding of the fundamental nature of the reaction. While a fair measure of agreement on general detail has been reached it is quite clear that a very large number of variables are involved and a vast amount of work remains to be done. This has become even more evident since the comparatively recent discovery of the phenomenon of cocatalysis and the fact that the true chain initiators may be complexes between catalyst and trace impurities, solvent, or even monomer.

In this present state of the subject a normal type book would be premature. I believe, however, that Dr. Plesch has succeeded in the present volume in satisfying the intense interest in the subject by producing what is in effect a progress report by the most eminent workers in the field. There is reported here, with copious references to earlier work, a good deal of representative material which has been published in recent years together with some which will shortly appear. Most valuable of all, however, are the comments and suggestions made in discussion. The whole has been arranged, presented, and printed in a most attractive and readable fashion.

After a foreword by Sir Eric Rideal, the preface by Dr. Plesch gives a historical survey and puts the later discussion in perspective by showing in particular the economic and industrial aspects of the subject and also its relationships to modern theories of organic chemistry. Thereafter the book is divided into two main sections approximately equal in length. The first is devoted entirely to papers on complex formation with a direct bearing on the initiation process, while the second includes papers on the polymerization process itself. These are summarized by Prof. D. D. Eley and Prof. F. S. Dainton respectively.

Adverse comment is of a trivial nature and detracts not at all from the value of the book. It is concerned only with minor points of inconsistency in presentation. For example, Ph and C_6H_5 are used, even in the same equation (p. 76), to represent the phenyl group and the appearance in the text sometimes of [ ] while at other times "the concentration of" is written in full. These points may be rather difficult to avoid, however, in a publication of this nature where the original material has come from a number of authors.

This book gives an authoritative account of the state of our knowledge of cationic polymerization at March 1952. It is of particular value to all interested in the general fields of high polymers and complex formation and must be indispensable to workers in the more restricted field which it covers.

N. Grassie

TECHNIQUE OF ORGANIC CHEMISTRY

Technique of Organic Chemistry

Vol. 8: Investigation of Rates and Mechanisms of Reactions. S. L. Friess and A. Weissberger (Editors). Pp. xxiii+760. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1953.) 12.50 dollars.

THIS volume surveys the broad domain of chemical kinetics. The editors have sought to present theoretical as well as practical techniques, and topics outside the scope of formal kinetics are treated when relevant to the problems of reaction mechanism. The initial chapters are relatively general and are devoted to the theory of chemical kinetics, to experimental methods of measuring

reaction-rates, and to the principles underlying the elucidation of mechanism: later chapters are more specialized and refer to gas-phase reactions, liquid-phase reactions (and homogeneous catalysis), polymerization and polymer reactions, biological reactions, and very fast reactions. Heterogeneous reactions, heterogeneous catalysis and other bi-phase processes are not treated.

Viewed as a whole this is unquestionably a useful source-book for chemists whose interests lie within or on the fringe of the field of reaction mechanism. The least successful aspects are the purely theoretical parts, for the absolute rate theory which is the natural foundation of the main sections of the book is very summarily presented, the degree of condensation being such that in some respects the foundation is insecure. For example, in the discussion of the effect of isotopic substitution (p. 26) it is claimed that, a C—H bond being replaced by C—D, the *maximum* theoretical ratio of rate constants is 4·3. Actually, the author has calculated (approximately) the 'maximum' velocity ratio for a special, and certainly very rare, case in which the deformation vibrations have the same frequency in the ground and transition states; but none of this is explained. Probably no one will be misled, but it is disturbing to find several references to this 'derivation' at points later in the book.

The field covered in this volume is broad and correspondingly difficult to survey; but the authors have maintained in general a very even and interesting level. In a treatise on the methods of organic chemistry it is natural that liquid systems receive the most attention; but not the least useful sections are devoted to the theory and practice of relatively specialized techniques: for example, flow methods, which are becoming increasingly popular. It may, perhaps, be regretted that the section on rapid reactions is restricted to biochemical systems or to systems primarily of biochemical interest: no account is given of the investigation by ultrasonic and other new methods of simple, very fast reactions in the gas phase.

Binding and presentation conform to the high standard of the series, and a cumulative index to the earlier volumes is provided. J. C. D. BRAND

RUSSIAN PROGRESS IN ELECTRON DIFFRACTION

Electron Diffraction

By Prof. Z. G. Pinsker. Translated by J. A. Spink and E. Feigl. Pp. xiv+443+25 plates. (London: Butterworths Scientific Publications, Ltd., 1953.) 63*s*. net.

THE appearance of a translation of this important Russian book is very welcome. A specially contributed preface by the author suggests that Russian scientists are anxious for international co-operation, and this would be greatly helped by the appearance of further translations of this kind.

As an orthodox work on the theory and practice of electron diffraction, the book is very good; it deals with the elements of wave theory, the diffraction of waves by crystals, experimental methods, apparatus, and practical results. The chapters on the last subject appear to deal fairly with Russian and non-Russian contributions, and it is evident that, in some types of electron-diffraction work, the Russians are well ahead. This is particularly true of crystal-structure determination; since electrons are scattered by the field within an atom and not by electron density, hydrogen atoms are more easily detected by electrons than by X-rays, and work on this subject has been appearing in the Russian literature since 1948. As far as the reviewer is aware, the earliest comparable work in English is that of Cowley in Australia, published in 1953.

As a historical commentary, however, the book has several defects. For example, the discovery of electron diffraction is attributed solely to Davisson and Germer, Thomson's work being referred to, only incidentally, several pages later. Quite naturally, Russian work receives predominant attention; but it comes as a shock to find W. L. Bragg given only minor honours for what is usually known as Bragg's law; Prof. Pinsker consistently refers to this law as the Wulff–Bragg law, claiming that it was discovered by "the Russian scientist Wulff (*Phys. Z.*, **14**, 217; 1913) and simultaneously Bragg (*Proc. Camb. Phil. Soc.*, **17**, 43; 1912)".

This claim deserves some attention, since simultaneity can be claimed only if the later paper were received before the earlier one was published. In this instance, this is not so; Bragg's paper was *published* in November 1912, and Wulff's was not *received* until February 1913. Moreover, Wulff's idea arose out of a note published by Bragg in *Nature*, in December 1912, to which Wulff refers in his paper. Thus the claim for a division of the honours cannot be substantiated, even though Wulff was clearly unfortunate in that Bragg's paper was published in a journal which was probably not well known to him.

The translation has been carried out extremely competently, even if the English is inclined to be a little stilted in parts. The translators have added to the value of the book by including many extra references, and the author has contributed some recent Russian ones in his preface.

The book can be confidently recommended as an important work on the subject. H. LIPSON

RADIOACTIVE ISOTOPES

Radioactive Isotopes

An Introduction to their Preparation, Measurement and Use. By W. J. Whitehouse and J. L. Putman. Pp. xvi+424+5 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1953.) 50*s*. net.

DURING the past decade the number of applications of radioactive isotopes has increased enormously, and the concomitant growth of interest has created a demand for appropriate text-books. For those who wish to read about the preparation of radioactive isotopes, their properties and uses, "Radioactive Isotopes" constitutes an excellent survey. The treatment is comprehensive and well balanced and the presentation generally lucid and precise: furthermore, the book arouses and maintains interest.

After a brief survey of the nuclear reactions which are used in the production of radioactive isotopes, the modes of nuclear disintegration are discussed together with the properties of the radiations. These topics occupy about a quarter of the book and they constitute the background for the remainder of the text. The authors then deal with the practical

production of isotopes in uranium piles and cyclotrons, and the reader is given a clear description of the requirements for these processes. More stress might have been laid, however, on the high specific activities produced by the Szilard–Chalmers effect.

The chapter on the detection and measurement of the radiations includes sections on units, Geiger counters of various types, proportional and scintillation counters. Absolute and relative counting are both considered and a section is devoted to the statistics of counting experiments. Adequate reference is made, for example, to the comparison of radioactive sources under exactly similar conditions. It is a pity that occasionally one is left in doubt about the exact scope and limitation of a few of the counting methods. The addition of more numerical examples, here and elsewhere, would add greatly to the value of the book.

The authors describe the gross effect of the radiations, the production of ionization and the physical and chemical consequences. Dose units and dose rates from various sources, ionization chambers, electrometers, and calorimeters are discussed. The chemical aspects are dealt with very briefly.

The treatment of the applications of radioactivity lays stress on the principles and validity of the methods. The radioactive isotopes and their compounds can be used as markers, tracers and sources of radiation, and illustrative examples are widely chosen from physics, chemistry, biology, medicine and industry: sound advice is offered on the design of experiments. The book finishes with a description of manipulation techniques and hazards, and a useful table of many radioactive isotopes.

The index would be improved by including some of the more common isotopes. Throughout the book, graphs and formulæ have been presented in useful forms, and many references are made to original papers, reviews and books: readers who wish to translate the written word into action will find valuable information in this book, though those who are not physicists might appreciate more information on the characteristics of the ideal electronic equipment to be used in conjunction with radioactive isotopes. This would enable an experimenter to assess the power packs, amplifiers, scalars and other equipment available commercially.

In spite of these minor criticisms, the book can be thoroughly recommended. S. J. Thomson

DISCHARGES IN GASES

Electrical Breakdown of Gases

By J. M. Meek and J. D. Craggs. (International Series of Monographs on Physics.) Pp. ix+507. (Oxford: At the Clarendon Press; London: Oxford University Press, 1953.) 60*s*. net.

Sir John Townsend advanced his theory of ionization by collision in 1900 and his theory of the unstable discharge in 1903 (in *The Electrician*). The brilliant researches he afterwards conducted and described in his 1915 book "Electricity in Gases" gave most readers the impression that the fundamental theory of discharges was known and that it remained but to apply it. After 1920 this optimism disappeared mainly because the principles of the interactions between electrons, ions, molecules, radiation and solid surfaces were incompletely known and because the range of possible conditions permits a remarkable proliferation of phenomena. The great volume of research undertaken since then provided a vast quantity of observed data, greatly improved experimental methods and valuable deductions within limited fields, but the general theory did not greatly advance. Since the Second World War, it has come to be appreciated that Townsend had the roots of the matter and that, with the aid of contemporary advances in physics, workers on discharges can begin to see the complete tree.

Prof. Meek has for long been one of the foremost contributors to the subject, at first with Dr. T. E. Allibone, then with Prof. L. B. Loeb and now with the school he founded himself at Liverpool, in which Dr. Craggs plays a leading part. The authors of "Electrical Breakdown of Gases" are thus essentially qualified for their task of summarizing knowledge of unstable conduction in gases. Their book is as complete as its five hundred pages and profuse, and often beautiful, illustrations allow. It is highly compressed and its twelve chapters have impressive bibliographies. One can only hint at its scope. The first five chapters give the principles of ionic motion, the mechanisms of ionization and recombination, and the concept of the two Townsend ionization coefficients which together can multiply the ionization into an avalanche and can make the discharge self-maintaining. In the light of these principles the behaviour is discussed of discharges at low pressures, then the corona and the spark at higher pressures, where they are distinct phenomena, and finally the lightning discharge, which is the leading example of the long spark caused by a transient voltage. Chapter 6 essays a quantitative theory of the spark based mainly on the streamer and radial-field hypothesis. Chapter 7 deals with the numerical sparkover voltages in cases of practical importance, including the uniform field, the sphere gap and concentric cylinders. Chapters 8, 9 and 11 cover studies ancillary to or somewhat removed from the main analysis, namely, the influence of ionizing radiations, discharges at high frequency and electrode effects. Chapter 10 considers the detailed structure of the actual spark channel as obtained by recent experimental techniques and relates it to theory. The final chapter deals with the important problem of the transitions from the high-resistance glow to the low-resistance arc condition, which may occur in time or in space. Throughout the book reference is made to important engineering and scientific applications at points where the principle discussed is that which determines the application.

The appendix on recent developments might be thought to support a criticism that the authors should have waited to see whether current work is ultimately successful in simplifying some explanations, for example, the direct application of Townsend's equations by Prof. Llewellyn Jones. On the other hand, any later simplification would be offset by the discovery of new phenomena and a valuable and necessary book would stay unwritten. Similarly, though some may think the authors take rather an individual point of view on controversial issues, such as the streamer theory, yet they refer to those who disagree with them, so that the reader can examine the literature and decide for himself. If books are to be written by those who are building up the subjects they treat, then such books must necessarily reflect the original research of their authors. Prof. Meek and Dr. Craggs have written a book which every physicist or engineer interested in gaseous discharges should not merely read but should always consult. S. Whitehead

NUCLEAR REACTOR THEORY

The Elements of Nuclear Reactor Theory

By Samuel Glasstone and Milton C. Edlund. Pp. vii+416. (London: Macmillan and Co., Ltd., n.d.) 35*s*. net.

SOME of the results of the research and development which were necessary in order to produce the atomic bomb have gradually been made available in scientific journals and in the well-organized volumes of the National Nuclear Energy Series. Hitherto, however, no comprehensive account has been given of the theoretical work underlying the design and operation of nuclear reactors. With the current interest in the utilization of atomic power and the establishment of a nuclear reactor as a valuable fundamental research tool, such a book is long overdue.

Dr. Glasstone and Mr. Edlund have most ably filled the gap with their recent book on nuclear reactor theory. This book is based on a course of lectures which is given at the Oak Ridge National Laboratories for graduates who are commencing work on the reactor research and development programme. As such it is written primarily for physicists and engineers but is of interest to all concerned with reactor design.

For those unfamiliar with the properties of neutrons and their interaction with matter four introductory chapters are provided. These deal with such fundamental concepts as nuclear structures, binding energy, energy-levels, cross-sections and radioactivity, culminating in a discussion of the fission process and a chain reaction. The book is restricted, on security grounds, to a discussion of 'thermal' reactors, which are reactors in which the majority of fissions are caused by neutrons the average kinetic energy of which is approximately equal to that of the atoms and molecules in the containing medium.

This introduction is followed by a detailed mathematical treatment of the behaviour of neutrons in matter. The slowing down of fast neutrons from fission is developed according to Fermi's continuous loss of energy model and their subsequent behaviour according to diffusion theory. The application of this work to the design and properties of homogeneous and heterogeneous reactors is given in two later chapters. A discussion on reflectors includes an indication of the value of the group diffusion method for describing the slowing down of neutrons. This is also considered in a chapter on the general theory of homogeneous multiplying systems.

It is gratifying to find that the authors have found space for this chapter and also for one dealing with the relation between diffusion theory and the more exact transport theory. Such considerations are essential in order to understand in what circumstances the simple treatment given earlier becomes invalid.

There are also separate chapters devoted to reactor kinetics, reactor control and perturbation theory. The effects of control rods and delayed neutrons are calculated, and brief mention is made of the effects of fission products and variation of reactor temperature. It is a pity that space could not be found for a discussion of the use of perturbation theory in treating the two latter effects, which are of considerable practical importance.

A comprehensive subject-index is provided, and at the end of each chapter there are several problems which are of practical interest. Sufficient declassified data are given for the reader to design reactors for himself and to determine their operating characteristics. Some scarcity of references is understandable in a book which is produced under security restrictions, but more references to experimental work which has been published might have been made.

This book can, however, be thoroughly recommended to those who are interested in reactors and wish to know more about their design, to those who are joining a reactor project for the first time and as a reference book to those who have managed without one for so long. P. W. MUMMERY

RECENT RESEARCHES IN PHYSICS

Reports on Progress in Physics

Vol. 16 (1953). Executive Editor: A. C. Stickland. Pp. iv+407. (London: The Physical Society, 1953.) 50*s*. net; to Fellows, 27*s* 6*d*. net.

THIS, the sixteenth in the series of now annual reports, differs little in outward form from its predecessor. As in Vol. 15 there are nine articles each dealing with advances in a particular field or branch of physics. The standard is high and the reports contrive to get more and more specialized. No longer can the physicist of average attainment or the specialist in a particular branch hope to gain easily by reading these reports an insight into interesting developments outside his present knowledge. The authors assume that their readers have more than a nodding acquaintance with their subjects, and they do not bother to give an adequate introduction or to explain fully and simply the terminology and methods used. Far too many aspects are covered in the one article, and it is obvious from the large number of references which accompany each report that only a few lines of text can be devoted to the work described in each of the papers referred to. Authors of future reports might be invited to provide more background material and to deal more broadly but critically with the important advances in the fields they choose to survey.

The present interest in solid-state physics is reflected by the comparatively large number of reports, five of the nine, dealing with various aspects of crystal and solid properties. The first, which is also the longest article in the volume, is by G. E. Bacon and K. Lonsdale and is devoted to a review of the application of neutron diffraction methods to the examination of the structure of solids. Now that neutron beams of considerable intensity are available from atomic piles, progress in the study of the interaction of neutrons with matter has been rapid in recent years. The report deals in particular with the way in which neutron diffraction has been used to supplement studies by X-ray diffraction, and with structural investigations involving light elements, distinctions between atoms of closely similar atomic number, and studies of magnetic materials.

The relation between the magnetic, optical, piezoelectric and elastic properties of crystals and their structural characters is discussed in a brief report by W. A. Wooster. This is a difficult subject and the experimental data are still inadequate, particularly in reference to the elastic constants, to justify more than broad generalizations. Dr. Wooster deals adequately with the material available. An admirable summary of work done mainly during the past five years on the Raman effect is given in the next report by A. C. Menzies. It is fitting that an article on this

effect should be included in the present volume because the twenty-fifth anniversary of the discovery of the effect by Sir C. V. Raman, who originally used sunlight and complementary filters, occurred last year. Appended to the report is an excellent bibliography which is self-explanatory and largely supplements the text of the article. An attempt is made to provide those not closely engaged in Raman work with a summary of early investigations and with definitions of the technical terms used. A brief statement of what the Raman effect is would perhaps also have been useful.

A report of considerable value, probably the first comprehensive report on the subject, is contributed by B. Bleaney and K. W. H. Stevens, of the Clarendon Laboratory, Oxford. It deals with paramagnetic resonance or the electronic magnetic resonance of loosely coupled systems. The experimental techniques and theory are explained, and mainly only those particular aspects of paramagnetic resonance which are well understood are discussed. A close study of the subject and allied topics has been made by the Oxford group of workers under the supervision of Dr. Bleaney, and the authors of the report give an impartial and authoritative description of what has so far been achieved. However, the mathematical relationships look extremely formidable and it is also difficult for the reader to appreciate what is the real importance and significance of the mass of data, both experimental and theoretical, that is being accumulated.

The final article in the group on solid-state physics is entitled "Semiconductor Circuit Elements" and is written by J. S. Blakemore, of Standard Telecommunications Laboratories, Ltd., and A. E. De Barr and J. B. Gunn, of Elliott Brothers (London), Ltd., Research Laboratories. In spite of its title only a small portion of the report is devoted to the technological applications of semiconductors in the form of diodes, photocells and counters, transistors and other circuit elements. The remainder consists of an excellent, concise treatment, using statistics and band theory, of the electron physics of metals, semiconductors and rectification at metal–semiconductor contacts and p–n junctions, followed by an informative discussion of the bulk properties of semiconductors.

Five pages of references accompany the forty-three page article on electrical discharges by F. Llewellyn Jones. Recent developments are surveyed under the main headings of the electrical breakdown of gases in static fields; high-frequency discharges; cold electron emission in discharges; and the régime of space charges. This report supplements several previous reports on the subject. The existence of spontaneous fluctuations sets a limit to the accuracy which can be obtained in the measurement of a physical quantity in a prescribed way, and a valuable account of the ways in which fluctuation theory has been applied to some of the simpler systems—suspended systems, electrical circuits, radiation detectors and feedback—of physical measurement is given in the report by C. W. McCombie. All experimental physicists should study this article, though they may find the theoretical details somewhat difficult to follow.

The remaining two reports in Vol. 16 differ from the rest. They are perhaps the best and the most appealing, one—on cosmology, by W. H. McCrea—because the author makes no pretence at writing a review of recent work, and the other—the new unstable cosmic-ray particles by G. D. Rochester and C. C. Butler—because it deals with a new field of particle physics which will engage the attention of physicists for many years to come. In the former the main purpose is to describe the lines of thought and to discuss the aims and methods of cosmological theory and not to give a detailed comparison of theoretical and experimental results. The main current theories of cosmology and the model universes yielded by them are reviewed and critically examined, and the general physical features of the actual universe that may be inferred from its comparison with the various theoretical models are discussed. In the latter a detailed description is given of the properties of particles with masses between 400 and 2,200 electron masses. The authors were the discoverers of the neutral V-particles, and the evidence for these and related particles as shown in Wilson cloud chamber photographs of cosmic-ray showers is amply illustrated in a series of beautiful illustrations.

Volume 16 is excellently produced; but there is no index. The reports were again under the general supervision of the Papers Committee of the Physical Society under the chairmanship of Prof. S. Devons, and the executive editor of the publication is Dr. A. C. Stickland, the secretary-editor of the Society.

S. Weintroub

THE OXIDATION OF METALS

Oxidation of Metals and Alloys

By Dr. O. Kubaschewski and B. E. Hopkins. Pp. xv+239. (London: Butterworths Scientific Publications, Ltd.; New York: Academic Press, Inc., 1953.) 35s. net.

During the past fifteen or twenty years there has been a remarkable improvement in the capacity of metals and alloys to withstand high temperatures under service conditions. The jet engine and the gas turbine have been made possible by the skill of the metallurgist in providing alloys with improved resistance to both creep and oxidation. Generally, more prominence has been given to the improvements in mechanical properties, for these have been the more difficult to achieve and have been made only as the result of great and sustained effort, involving considerable man-power and expensive and impressive creep laboratories. Yet no improvement in mechanical properties would have been of value if it had not been accompanied by adequate resistance to oxidation. The oxidation of metals is therefore a very vital and topical subject for the technologist no less than for the fundamental scientist, who still finds tantalizing problems to be solved in this field. In making a critical survey of the work that has been done on the oxidation of metals the authors have undertaken a task that badly needed doing. The preface states that they have written from the point of view of the individual who is midway between the technologist and the theoretical scientist, but anyone interested in oxidation, from whatever angle, should find this book valuable.

The first chapter reviews the basic information on oxidation and includes useful tables of thermodynamic data, which may be used in deciding which oxide is likely to be formed on an alloy. It is stressed, early on, that most metals and alloys are unstable in air even at room temperature and that therefore the main interest is in the kinetics of oxidation—how rapidly is the oxide formed and what law is obeyed.

As an introduction to the later treatment of mechanism, this chapter includes brief but useful discussions of diffusion and electrical conductivity, and reviews the structures observed in films and scales as well as the effects of gas pressure and temperature on oxidation.

Many experimental methods have been used for the examination and measurement of oxidation; their advantages and limitations are here discussed and illustrated by typical applications. Descriptions of the techniques are brief and the reader is referred to other sources for operational details.

The parabolic oxidation–time law resulting from a diffusion-controlled process is obeyed by many metals within certain limits of temperature when the oxide film has become relatively thick. Accordingly, the authors give a fairly detailed exposition of Wagner's theory of parabolic oxidation and conclude that, within its limits, it may be of great help in the development of oxidation-resistant alloys.

Since it was intended that the emphasis of the monograph should be on fundamental principles and theories of oxidation rather than on oxidation-resistant alloys, it is appropriate that the experimental results should be reported in the final chapter in a somewhat condensed form. In spite of this, the treatment is comprehensive and co-ordinated and the reader will quickly find which original papers are of interest to him. Nearly 550 references are given and there are 84 figures.

Altogether this monograph makes a useful addition to the literature on the subject, and can be thoroughly recommended. A. G. QUARRELL

ELECTRONS IN METALS

The Theory of Metals

By A. H. Wilson. Second edition. Pp. viii + 346. (Cambridge: At the University Press, 1953.) 45*s*. net.

MANY of the basic principles of the electron theory of metals had been established in the early days of the development of quantum mechanics. By the time the first edition of this well-known book was published in 1936 it was possible to give a theoretical interpretation of many of the salient features of metallic behaviour. The developments since that time, making the appearance of a new edition especially welcome, have been fourfold. First, the mathematical theory has been further advanced. This advance has on the whole been beset with many difficulties and has been slow. Many outstanding problems remain only partially solved, particularly those connected with inter-electronic and electron-lattice interactions having applicability to such physical properties of metals as ferromagnetism and superconductivity. Secondly, there has been a marked improvement in the methods and techniques of numerical calculation. Thus, more accurate values of electronic energies have been obtained by the approximation methods described in the book, and, again, the fundamental transport equation governing conductivity phenomena has been solved with greater accuracy and reliability. Thirdly, it has been realized to an even greater extent that the theory is often so intricate that significant advances may only be possible if increased attention is paid to the analysis of the results of high-accuracy experiments, such results being now forthcoming in growing, though not yet sufficient, numbers. Finally, there has been a growing realization that the theory of metals, far from being a purely academic field of study, has many applications in technology. An understanding of the theory of semiconductors, for example, to which the author has made such distinguished contributions, has led to the development of the transistor.

Solid-state physics is now a popular field of research, second in volume of significant output perhaps only to nuclear physics. An authoritative account of many aspects of this field, such as is provided in this book, will have a wide appeal. The fact that the theory of metals has come to cover such a wide range of diverse topics has made the inclusion in this book of only selected aspects almost inevitable. By far the greatest weight is given to the theory of conduction. The historical introduction deals with the development up to the Sommerfeld theory, and the formal theory of conduction, deducing the consequences of assuming the existence of a time of relaxation, is discussed in a later chapter. Here a theoretical discussion of one or other of the various 'effects' is usually followed by a survey of experimental data. The theory at this stage is formal, and the following chapter aims at removing this blemish by a detailed examination of the mechanism of conductivity and the physical significance of the time of relaxation. The mathematics is difficult, which is scarcely surprising, considering the complexity of the interaction of electrons with lattice vibrations and impurity atoms. The results of the analysis are not always in agreement with experiment, sometimes not even qualitatively so. Such discrepancies, as in the theory of thermal conduction, do not generally mean that the theory is 'wrong'. The physical situation being so involved, they are more likely to be the result of one or other of the simplifying approximations which make a development of the theory possible at all. Indeed, advances in this field are often consequent only on a re-examination of the validity of such approximations following the discovery that theory and experiment disagree. Other chapters on conduction phenomena include one on semiconductors and a final chapter on the application of the variation principle to the solution of the transport equation, a recent and fertile development in the theory.

Other topics in metal theory are discussed more briefly; nevertheless a surprising amount of detail not generally found in other books is included. Few accounts deal as adequately with the properties of the differential equation governing the motion of electrons in perfect crystals. An important chapter discusses adequately, though in only some forty pages, the various metallic structures as well as their Brillouin zone geometry, and also gives an account of the results of various energy band calculations, of the problems of metallic cohesion and of X-ray spectra in metals. Other chapters discuss the thermal and magnetic properties of metals, including an extensive account of the difficult theory of diamagnetism. A separate chapter treats ferromagnetism from the point of view of the collective electron theory.

In view of the general excellence of this book it is perhaps ungracious to voice one general, even intangible, criticism. The book appears to have too much of the appearance of a treatise on the subject, much as a standard work on some classical branch of mathematical physics. The very fact that there is still great scope for improvement in the theory, especially of its quantum mechanical aspects, is somehow veiled by the inclusion of so many detailed

mathematical deductions from premises based on some theoretical model used, perforce, in the absence of a sounder quantum mechanical description. The elegance of the mathematics should not give the reader a false sense of security, nor blind him as to the possible inadequacies of a particular model in giving an accurate description of what may be a very complex physical situation, of which no mathematical description in closed form may, in fact, be strictly possible.

E. P. Wohlfarth

METALLURGY AND ATOMIC THEORY

Atomic Theory for Students of Metallurgy

By William Hume-Rothery. (Monographs and Report Series, No. 3.) Second (revised) edition. Pp. 331. (London: Institute of Metals, 1952.) 21*s*.

THE first edition of this book was published in 1946; it has since been reprinted twice, and now we welcome the appearance of a second edition in which several chapters have been amplified and brought up to date. It is an indication of the steady advance of the subject that a book of this kind, written primarily for honours degree students, should require such additions after so short a period; and the book itself is an indication of Dr. Hume-Rothery's determination to keep students of metallurgy abreast of developments in the fundamental aspects of their subject.

The recasting of this book has increased its size by forty-five pages, and meticulous care has been taken to present the latest data on each subject. For example, the old phase diagram of the copper–gallium system, used primarily for the purpose of illustrating general principles, has been replaced by a later and presumably more accurate one. Again, in the general introduction of Chapter 1 and in the well-known table of electronic configurations, we now find data referring to the transuranic elements. Some of the most interesting of the new material which this edition contains is to be found in Chapter 27 and concerns the behaviour of what are called defect structures. These are alloys in which the electron concentration appropriate to the phase is maintained, during changes of composition, by the creation of vacant lattice sites.

Chapter 29 deals with the difficult problem of the transition elements, and has been considerably extended in the second edition. This is, perhaps, unfortunate. In the introduction to the first edition we are told that "it has been thought better to concentrate mainly on the properties for which the theories have provided a reasonably straightforward explanation, and to avoid those whose interpretation is still in doubt". However, in this chapter, and to some extent in the succeeding one, we find theories which, to put it mildly, have not received general acceptance and which, in truth, are based on vague and unsatisfactory concepts. It is, however, a great merit of this book that none of the theories presented is expressed dogmatically, and little harm should result to the intelligent student if, in fact, some of the hypotheses prove to be wide of the mark. Moreover, there can be no doubt whatever that great benefit will be derived by all who study this excellent book as a whole, and who appreciate its true purpose.

H. Jones

KINEMATICS OF MECHANISMS

Kinematics of Mechanisms

By Dr. N. Rosenauer and Dr. A. H. Willis. Pp. 395. (Sydney: Associated General Publications Pty., Ltd., 1953.) £(A)4 10*s*.

PROF. ROSENAUER, who lectured on mechanism for many years in the University of Latvia, is now on the staff of the New South Wales University of Technology. The many contributions he has made in this field have been published in various learned journals of Continental Europe, where he enjoys a considerable reputation. This book is based upon his lectures and incorporates the fruits of much of his own research. It is a remarkable book in that it is the first publication on this topic which has appeared in the English language for a great many years. It is to be regretted, however, that the authors did not bear this fact in mind when writing it, for the British or American reader lacks the background possessed by his Continental counterpart, where the subject of kinematics has long been intensively studied. The approach adopted in Britain, in so far as the subject is treated at universities at all, is basically different: we do not lay much store by the extraordinarily thorough enumeration and examination of particular cases, so typical of German texts, to which this book is no exception. It is a large book and consequently costly; one feels convinced that if the material had been condensed to about one-third of its present bulk, and the price correspondingly reduced, the book would have gained not only in attractiveness but also in clarity, for fundamental methods and principles might thus have emerged from their present concealment.

One appreciates that it is a relatively novel departure for an Australian publisher to produce a scientific work of this magnitude, and since it is such a laudable venture one hesitates to criticize the production, which leaves something to be desired by British standards: the paper is not really suitable for printing fine line-blocks, of which there are nearly four hundred, and no attention has been paid to the size of lettering for the diagrams, in the light of their future photographic reduction for block-making. The result is that the letters vary in height on different diagrams between 1/16 in. and 3/16 in.

Although British and American work in this field is scarce enough, it is regrettable that the authors omit mention of even this little. Some of the work on kinematic chains published in Britain in 1950 [1] is more general and more elegant than that given in the chapter devoted to this topic. There is no mention of 3-dimensional- (or space-) mechanisms, though an introduction to this topic would have been valuable, especially as it is in this field that there has been much American and some British activity in recent years.

The somewhat academic Euler–Savary and Bobillier methods, which take up much space, might well be omitted or mentioned merely in passing. On the other hand it is most useful to have, for the first time in book form, an account of Prof. Rosenauer's use of orthogonal velocity vectors on which are based many of the constructions in this book.

The final chapter is entitled "An Introduction to the Synthesis of Mechanisms". To design a mechanism to meet a given specification is, of course, the engineer's whole object in studying the kinematics of mechanisms. One or more points of the mechanisms are required to approximate as closely as possible to

a given motion, both in position and velocity, with limitations on the permitted accelerations of all parts of the linkage. There can be no question but that British mechanical design would benefit considerably if the underlying principles of kinematic synthesis were more clearly enunciated and more widely known. This chapter is a step in the right direction, but a far more fundamental examination and exposition of the properties of the four-bar chain are required to fill the present gap. Such matters as are treated in the chapter on straight-line motion would fall out of such an analysis as important special cases. Until such time as this is attempted, the designer will be content to rely upon atlases of curves, such as those recently produced at the Massachusetts Institute of Technology.

The authors and publishers are to be congratulated on their production of a most valuable book. It is sincerely to be hoped that this pioneering effort will inspire others to enter the field with works which will be of more direct value to practising engineers and which will make a greater appeal by adopting a fundamentally different approach, more in tune with the British engineer's background.

R. H. MACMILLAN

[1] Macmillan, R. H., "The Freedom of Linkages", *Math. Gaz.*, **34**, No. 307, 26 (1950).

THE ART AND SCIENCE OF DESIGN

The High-Speed Internal-Combustion Engine

By Sir Harry R. Ricardo. Fourth edition, rewritten and reset. Pp. ix+420. (London and Glasgow: Blackie and Son, Ltd., 1953.) 40*s*. net.

SOME years ago the reviewer was discussing tank design with one of its leading German exponents, who prefaced his comments on tank engines by remarking that German designers had found their inspiration in the translation of an early edition of the present book, and that he could not understand why so little attention had been paid to Ricardo's work in his own country.

Although this book is called the fourth edition, comparison with the third edition quickly shows that the impression thus given is entirely misleading; both books should be found on the shelves of every engineer, since not only does each contain much that is not to be found in the other, but also, taken together, they offer a fascinating insight into the workings and development of a powerful mind faced with the creative problems of design and manufacture.

Sir Harry Ricardo, in his presidential address[1] to the Institution of Mechanical Engineers, presented an autobiographical sketch of his development as an engineer which held his audience spellbound. Into this, his latest monograph, he has distilled such balanced wisdom on his own special field as every designer would wish to be able to do. Here are to be found the analysis of much research work, carried on over a period of almost fifty years, the experience and the conclusions he has drawn from it, the guesses and the surmises, the rational and the apparently irrational preferences; in short, the whole wealth of mind that is needed for great creative engineering. No engineer who has reflected on the problems facing himself can fail to be stimulated by the unique presentation; yet at the same time the book is such as should be made compulsory general reading for every engineering undergraduate. It is, indeed, a cause for reflexion that Ricardo started on the research work that was to shape his life's work when Bertram Hopkinson suggested to him that he should stop reading for the Mechanical Sciences Tripos at the end of his first year in order to assist in Hopkinson's work on knock, and thus left Cambridge labelled only with a pass degree.

While the chapter headings suggest that this is a comprehensive work on the high-speed internal combustion engine, its weakness as its strength is that it makes no pretence at being other than a monograph. There are neither footnotes nor references, nor is there more than occasional remark on the sources on which the author has drawn beyond his own laboratories; thus the reader unacquainted with the field might be led to accept as gospel certain matters which are open to dispute, and in matters where he might like to study more deeply, no clue is available as to where he should turn for more detailed information. This, however, is carping criticism, since an engineer whose writings display the full apparatus of scholarship is scarcely likely to have found time for the hard and laborious work involved in great mechanical design. D. B. WELBOURN

[1] *Proc. Inst. Mech. Eng.*, 152, No. 2, 143 (1945).

LOGIC FOR MATHEMATICIANS

Logic for Mathematicians

By Prof. J. Barkley Rosser. (International Series in Pure and Applied Mathematics.) Pp. xiv+530. (London: McGraw-Hill Publishing Co., 1953.) 85*s*.

THERE are many expert mathematicians who know little or nothing of symbolic logic. They have, of course, heard of Whitehead and Russell's "Principia Mathematica"; but cannot spare the time from their own researches to master its formidable difficulties. Now they have the chance to become acquainted with the subject much more easily. Prof. Rosser, by using Quine's technique, invented since the writing of "Principia Mathematica", claims to have condensed most of its three large volumes with its "out of date and extremely unwieldy symbolic machinery" into one book of moderate size.

The first chapter is addressed to those mathematicians who are not only completely ignorant of symbolic logic, but are also sceptical of its importance. This and the next four chapters seek to convert the unbeliever and to lead him very gently into the true faith, encouraging him by frequent references to the application of logical principles to ordinary mathematical theorems. But the reader who expects a mere confirmation of what he has always known will experience many shocks. "Some of these basic logical principles used by all (or almost all) mathematicians may actually not be valid. . . . Actually, some . . . have been subjected to severe criticism, notably certain uses of reductio ad absurdum". Moreover, "there is equally no guarantee that the symbolic logic is itself valid". However, from these principles—none known to be invalid, though some under suspicion—can be derived the existing body of mathematics, which is certainly useful in science and engineering.

The remaining ten chapters are more difficult reading; but even those who care little about logical technique will be interested by many references to ordinary mathematics. It is comforting, in these days of widespread references to electronic 'brains', to read that Alonzo Church's theorem proves that no machine can ever solve all problems solvable by a live mathematician. But mathematicians will not be pleased to be convicted of using the word function in two different senses, and thus producing confusion in a well-known treatise on the theory of functions. Much more disconcerting are the references to Gödel, Cantor, and the axiom of choice. According to a theorem of Gödel, "if a system of logic is adequate for even a reasonable facsimile of present-day mathematics, then there can be no adequate assurance that it is free of contradiction. . . . In fact, there is the awkward possibility that present-day mathematics is actually in serious error. . . ." "Cantor's theorem, to the effect that no class is similar to the class of all its sub-classes . . . is very useful in the classical theory of cardinal numbers. Unfortunately it seems to be false." But Prof. Rosser offers another theorem, which he believes to be true, to replace it.

There is a full discussion of the axiom of choice. Many mathematicians absolutely reject it. Some accept it readily, others with reluctance, doing so only because they believe that many valuable branches of mathematics are founded on it. Some who cannot accept the axiom in its usual form consider a weaker form, "the denumerable axiom of choice", far less objectionable, and on this a considerable amount of useful mathematics can be founded. ". . . to the best of our knowledge, one cannot prove the first fundamental theorem of Lebesgue without an appeal to the denumerable axiom of choice." "In topology, the axiom of choice is assumed from the very start. . . . Moreover, the question of how much topology could be done without the axiom of choice is apparently receiving no attention at all."

The last chapter sums up the principles established in this valuable and interesting book and applies them to an analysis of the merits and faults of some of the most esteemed mathematical treatises. It concludes with a bibliography and index. Nearly every chapter contains examples for solution. Every pure mathematician should read this book; unfortunately the very high price will mean that many will have to borrow it from a library, instead of buying a copy for themselves. H. T. H. Piaggio

NUMERICAL ANALYSIS

Numerical Analysis

By Prof. D. R. Hartree. Pp. xiv+288. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 30*s*. net.

Prof. Hartree's book makes a considerable step forward in the literature of numerical analysis. The subject has a long history. It arose originally from the needs of navigators and astronomers and in the earlier days consisted largely of trigonometrical and geometrical applications. Later, calculations were aided by the invention and use of logarithms. Then elementary statistics was added, so that by the time the standard text-book of E. T. Whittaker and G. Robinson came to be written, an appropriate title appeared to be "The Calculus of Observations", in spite of the fact that a large proportion of the book deals with finite differences and other tools of the makers and users of mathematical tables.

The Second World War greatly increased the demand for numerical work and stimulated the study of methods. In fact, numerical analysis is now recognized as a 'respectable' subject for mathematical study. Thus, although "The Calculus of Observations" has been a standard text-book for several decades, and remains a scholarly and useful book, it was written in the early days when computing was done with logarithms or with the earliest barrel-type hand machines. It is consequently lacking in numerical illustrations and examples adequate to present-day needs.

Other interesting and valuable books have also appeared from time to time, but they have either been too elementary to cover the most successful methods and formulæ of modern numerical analysis, or they have been advanced and specialized mathematical text-books on the theory of finite differences and difference equations.

A further line of recent progress has been the rapid development of automatic electronic computers, with fantastic speeds of performance of elementary numerical operations. With their development, there has grown up a considerable body of users who have not had prior training in computing with desk machines, and who are unfamiliar with the many useful techniques that have been developed. There is thus a tendency to use simple, repetitive or iterative, but above all obvious, methods of computation on electronic machines and to argue that such methods are appropriate for such machines.

There is, then, a clear need for a book for practical computers, whether working with desk or automatic machines, which will show them the kind of process which may or should be tackled numerically, which will tell them the best processes to use for carrying out the numerical work, and which will provide examples, both worked and unworked, to help them to attain a better understanding of the processes described.

Prof. Hartree's book meets all these needs. The aim of the book is practical, so that no attempt is made to cover ground beyond practical needs, interesting though much of this may be. For each process, the formula or method advocated as best is given in detail. Some further good methods are also described in case the author's choice should not quite meet the user's needs. Very considerable emphasis is placed on the importance of *checking* and on methods for doing this.

The derivation and use of finite difference formulæ is covered thoroughly, with almost exclusive emphasis on the use of *central* differences, followed by chapters on interpolation, integration and differentiation, and on the integration of ordinary and partial differential equations. Linear and non-linear algebraic equations, and matrices are covered fully, while a brief account is given of methods for summation of series, harmonic analysis, and smoothing (with adequate cautions on the often unappreciated dangers of this process).

A final chapter on the organization of calculations for an automatic machine gives an indication of possibilities that will be more and more widespread in the future.

This is a book that can be recommended for all computers of all ages—experienced or otherwise—and particularly as a text-book for students.

J. C. P. Miller

SHORT REVIEWS

Whipsnade

By Philip Street. Pp. 128+31 plates. (London: University of London Press, 1953.) 12*s*. 6*d*. net.

THIS is really a dual-purpose book: it describes the birth and development of Whipsnade Park and is an 'everyman's' natural history of the inmates. In addition, it takes everyman behind the zoological scene to make him understand the magnitude of the task of maintaining the Whipsnade estate and keeping the animals happy and healthy.

The history of Whipsnade makes most interesting reading and demonstrates the courage, energy and imagination of Sir Peter Chalmers Mitchell and Dr. Geoffrey Vevers.

It is depressing to read of the number of species which are either extinct or nearly extinct through the depredations of sportsmen and the demands of agriculture. There is a dramatic story of the rescue of the Père David deer by the tenth Duke of Bedford, who built up a flourishing herd from the eighteen known survivors of the species of which the thriving Whipsnade herd is an offshoot.

The natural-history section, well written and clear, leaves the reader speculating and anxious for further information; but as it is written for the layman it is rather misleading to say that most of the mammals in Australia are marsupials; except for some bats and the odd mouse the indigenous mammals of Australia were marsupials; but since man arrived placental mammals are gradually ousting the native fauna. The statement, too, that deer do not exist in Australasia is only partly true in that they have been introduced by man in recent times and the red deer is flourishing in New Zealand.

The omission of a chapter on the anthropoids seems a pity; but these are small blemishes on a book which tells of an exciting experiment, in language which is plain, undramatic and elegant and which should do much to send its readers to Whipsnade to see for themselves.

Journal of Researches into the Geology and Natural History of the Various Countries visited by H.M.S. *Beagle*

By Charles Darwin (1839). Facsimile reprint of the first edition. (Pallas, a Collection of Offset Reprints of Out-of-print and Classic Scientific Works, Vol. 2.) Pp. xiv+615+16 plates. (New York and London: Hafner Publishing Co., 1952.) 55*s*.

IT is now 127 years since a young geologist, aged twenty-seven, returned to England from a five-year voyage. At an age when most men are starting upon their careers, young Darwin had seen memorable service as naturalist in H.M.S. *Beagle*: his mind was full of information that was to be sifted, interpreted and re-interpreted until it became the basis of the "Origin of Species" more than twenty years later.

Despite all that is said to-day about Darwin and Darwinism there must be many who have not read the classic "Journal" in which the day-to-day discoveries were noted, and on every page of which the imprint of new experience is clearly recorded. One can still read the story for its intrinsic interest, with admiration for the tenacity, the physical toughness and the insatiable curiosity of the traveller.

Certainly the pleasure of reading is enhanced in this fine facsimile of the 1839 edition, which is clearly printed and has the original notes, illustrations and index. Some illustrations have been added from the earlier narratives of Captains King and FitzRoy, and the diagrammatic drawing of the *Beagle*, made many years later by Captain King, has also been included.

The closing words of the volume recommend travel as teaching "good humoured patience, freedom from selfishness, the habit of acting for himself, and of making the best of everything, or in other words contentment". Darwin also says "To hoist the British flag, seems to draw with it as certain consequences, wealth, prosperity and civilization". To these extracts one can only add: *O tempora. O mores.*

W. E. SWINTON

A Field Guide to the Birds of Britain and Europe

By Dr. Roger Peterson, Guy Mountfort and P. A. D. Hollom. Pp. xxxiv+318+64 plates. (London: William Collins, Sons and Co., Ltd., 1954.) 25*s*. net.

A GOOD handbook on European birds for use in the field has long been wanted. It is true that some thirty years ago Wardlaw Ramsay wrote a handbook on European and North African birds, but it had no coloured plates and the descriptions were more of birds in the hand than in the field.

In the present volume every bird is figured either in colour or black-and-white and, in addition, there are lines on the plates pointing to the principal different markings of any two birds which appear similar in life. Opposite the plates the chief characters of each species are clearly given, and as birds of prey are, as often as not, seen on the wing—they are shown in flight.

The introduction has valuable illustrated notes on how to identify birds, and where and when they are found, with a timely note of caution as regards rarities. The letterpress is short—a few lines on size and markings, a line or two on voice, and finally a short note on habitat and nests. At the foot of many of the pages are useful distribution maps.

The authors are to be congratulated on producing a veritable *multum in parvo* on European birds.

N. B. KINNEAR

Logic and Psychology

By Jean Piaget. Pp. xix+48. (Manchester: At the University Press, 1953.) 6*s*.

THIS small book is based on three lectures given in the University of Manchester in 1952. The brief historical survey in the opening chapter explains why there is little co-operation at the present time between logicians and psychologists. The second chapter deals with the four main stages, extending over the period from birth to maturity, in the psychological development of operations. Finally, the operational techniques of modern logic are used for discovering and constructing structures which can be put into correspondence with the operational structures of psychology, and the use of these logical structures in psychological interpretation is discussed.

The symbolic algebra used in the third chapter is more readily understood by the short survey, written by one of the translators, of the more important

concepts of the algebra of logic which Piaget has applied to the analysis of the intellectual activities of the child.

The book makes a further contribution to the study of the application of logical techniques to psychological facts, and especially to the thought structures found at different levels of intellectual development.

Man and Number

By Donald Smeltzer. Pp. viii+114. (London: Adam and Charles Black, Ltd., 1953.) 7*s*. 6*d*.

THE book gives an interesting account of the development of man's use of number and of the social and practical influences which have affected that development; it shows how early man acquired a sense of number and the gesture and spoken languages of number; it traces the evolution of the written language of number with early methods of recording numerical information and carrying out calculations to the wonderful inventions of modern calculation—the Arabic notation, decimal fractions and logarithms. The final pages of the book deal with inconsistencies and disadvantages in our present number system and how they might have been avoided by scientific planning. There is a useful bibliography but no index.

The appearance of such a book is a welcome addition to the small number of books on the history of mathematics of appeal to the general reader who is interested in human customs and their evolution, and to pupils in secondary schools. To the teacher of elementary mathematics the book will serve as an introduction to the more detailed works of Smith, Cajori and Rouse Ball, and as a source of material for inclusion in classroom lessons.

Earth Science

By Gustav L. Fletcher and Caleb Wroe Wolfe. Third edition. Pp. viii+556. (Boston, Mass.: D. C. Heath and Company; London: George G. Harrap and Co., Ltd., 1953.) 21*s*.

THIS book is primarily designed for teaching the background of physical geography and geology to students of, possibly, rather unequal attainments. Each chapter is conveniently paragraphed on the decimal system and followed by exercises. It is adequately illustrated by diagrams and photographs; examples are nearly all taken from the North American continent. The style of writing is simple and direct, with suitable typography; so from the students' point of view it is easy to read. Of the thirty-four chapters, twenty-one are devoted to geological subjects, four to astronomy, and seven to the atmosphere. These are followed by appendixes, a bibliography, and index.

Students of physical geology and geography must be presumed to have had a grounding in simple physics and chemistry; but the book includes some irrelevant, trivial and very elementary matter which makes it of uneven quality, and it contains several statements which are inaccurate or insufficient: for example, the assurance (p. 396) that "you are not likely to be struck by lightning if standing under a tree".

The list of books recommended for reading with each subject could well be extended, but deserves careful grading from elementary to highly advanced. The authorities cited are mainly American with a sprinkling of British, and there are some notable omissions from both sides. Much of the geological material and principles was anticipated in that little old classic, W. W. Watts's "Geology for Beginners", which surely ought not to have escaped the notice of the authors.

"Earth Science" is a compendium of useful information presented in a form easy to assimilate and to memorize; but it attempts both the formality of a text-book and the naïveté of a children's encyclopædia, and merits a careful pruning.

D. W. Bishopp

The Oxidation States of the Elements and their Potentials in Aqueous Solutions

By Prof. Wendell M. Latimer. (Prentice-Hall Chemistry Series.) Second edition. Pp. xvii+392. (New York: Prentice-Hall, Inc.; London: Constable and Co., Ltd., 1952.) 42*s*. net.

THE first edition was published in 1938 and had 352 pages. In it the author not only assembled the scattered mass of free-energy data, but he also expounded methods of combining these data for the determination of the thermodynamic properties of ions in solution and for the interpretation generally of chemical behaviour. The value of his work as a thorough survey of this important field was soon recognized. Prof. Latimer has now extended his tabulation so that for each element the heats of formation, free energies of formation and entropies have been given for all important compounds. Also, he has added potential diagrams for all elements having more than one oxidation state; he has treated reaction mechanism more deeply; and has inserted the chemistry of the actinide elements.

Of the four old appendixes, 2 and 3, summarizing free energies of formation and equilibrium constants respectively, have been incorporated in the text. A new appendix (3) discusses methods of making accurate estimations of entropy values; finally, a new appendix (4) contains a set of questions and problems for study. The book has already established itself as a standard work and the extension and revision have enhanced its usefulness.

G. Fowles

Small-scale Inorganic Qualitative Analysis

By Dr. J. T. Stock and P. Heath. Pp. iv+96. (London: University Tutorial Press, Ltd., 1953.) 4*s*. 6*d*.

WRITTEN by experienced teachers and entirely devoted to practical work, this is a complete book of small-scale analysis for students taking examinations of the British first-year university level. The introductory section of four chapters on apparatus, materials and techniques is extraordinarily well done. The descriptions of essential pieces of apparatus, such as the teat-pipette, the centrifuge, the micro-slide and the special hydrogen sulphide reservoir, are given with a clearness and directness that could come only from a first-hand knowledge of small-scale analysis and long experience of its teaching. Where circumstances may not permit of the acquisition of the recommended pattern of apparatus the authors often describe simple home-made substitutes. Chapters 5–18 describe a scheme for the analysis of simple mixtures of customary acidic and basic radicals using the detailed small-scale procedure. In the scheme the authors employ the excellent zirconium method for the removal of phosphate, make sparing use of organic compounds, and generally adhere to well-tried methods of separation and identification. A summary of the scheme

appears later in the book in the form of a series of tables. Semi-micro analysis has come to stay and older teachers, unacquainted with its techniques, could rapidly master this book and give instruction with confidence. G. FOWLES

Fundamentals of Chemistry

By Prof. L. Jean Bogert. Seventh edition. Pp. xx+648. (Philadelphia and London: W. B. Saunders Company, 1953.) 22*s*. 6*d*.

THE "fundamentals" are not only established but are also applied to medicine and the related arts. Of the book's thirty-two chapters nineteen deal with general chemistry and seven with organic compounds. All the chapters have been revised and some entirely rewritten: Chapter 18, on radioactivity and atomic energy, is new to this edition. In simple language and with unusual clarity Prof. Bogert gives a good introductory account of the elements and their chief compounds and of fundamental physical principles. He omits all mention of industrial processes and concentrates on the chemistry concerned with the living cell. Items of the contents illustrate this emphasis: colloids in the living organs, function of proteins in the body, physiological importance of oxidation, etc. The last six chapters deal severally with: the vitamins; digestion and the digestive enzymes; transportation, blood and lymph; metabolism; endocrine glands and their hormones; elimination, urine, and fæces. The versatile author excels in these chapters, for he has the rare ability of correlating his knowledge of chemistry and physiology, of selecting what is important and of expounding its significance. The book should appeal to students of medicine, hygiene and dietetics. In addition the reviewer would recommend it for the nursing school and for domestic science where this is taken at sixth-form level. G. FOWLES

Estimation of Organic Compounds

By Dr. F. Wild. Pp. viii+239. (Cambridge: At the University Press, 1953.) 25*s*. net.

THIS little book brings within two covers a collection of the various means of determining organic compounds through the characteristic groupings present; its scope is deliberately limited to general methods, so that the more specialized fields, for example, sugars, sulphonamides and amino-acids, are not considered.

The scheme adopted can be illustrated by the treatment accorded to olefinic linkages. Hydrogenation, both on the macro- and micro-scale, is described in detail, as are also methods for bromine, iodine and thiocyanogen numbers and the allied process using peracids; there are also a number of miscellaneous methods given in brief form. The inclusion of iodine numbers in a book of this kind is interesting, since it is usually necessary to refer to works on applied analysis of more specialized character for descriptions of such methods.

Other classes treated on similar lines are alcohols and phenols, mercaptans, aldehydes and ketones, amines, nitriles, nitro-, acetyl- and benzoyl-compounds and the lower alkyloxy- and alkylimino-compounds. A few others, for example, nitroso compounds and *iso*cyanates, are discussed in less detail. In some of the classes, particular methods for some individual members are included, for example, methanol (but not ethanol), formaldehyde, acetone. The Karl Fischer reagent is introduced under carbonyl compounds.

Experience would soon reveal that the 60 per cent strength quoted (p. 36) for a toluene solution of maleic anhydride is incorrect; the spelling 'xylidene', which occurs more than once, is unusual. These are, however, minor blemishes on a work which, with its companion volume in the qualitative field, will give the organic chemist a sound and useful start.

B. A. ELLIS

A Short Course in Organic Chemistry

By Harold Hart and Robert D. Schuetz. Pp. ix+326. (Boston, Mass.: Houghton Mifflin Company, 1953.) 4.50 dollars.

THE format, for a book of this class, is uncommon; its dimensions in inches, $10\frac{1}{4} \times 6\frac{1}{2} \times \frac{7}{8}$, and its large clear type permit of the bold presentation of important notes. The illustrations are varied and striking; indeed, the line drawings, the many plates in half-tone, the pictures of electron clouds, and the numerous ball-and-peg molecular models, disclose the authors' confidence in visual aid. The course, framed for adult students who need a working knowledge of organic chemistry but whose main interest lies in such fields as those of medicine, dentistry and agriculture, follows no prescribed syllabus. The scope is roughly the requirements in organic chemistry of the British university first-year course, but includes also the simple chemistry of petroleum, plastics, rubber, textiles, dyes, and explosives, as well as of vitamins, hormones and antibiotics. The approach is not by the study of alcohol, or by the analysis of organic compounds—a section entirely omitted—but by the electronic theory and the explanation of simple reaction mechanisms. The judgment shown in the selection and arrangement of the material is to be commended. The main emphasis is on biological aspects and on everyday applications of recent discoveries. The treatment is clear and interesting, yet a topic requiring effort for its understanding, such as optical isomerism, is not avoided. In general, aliphatic and aromatic compounds are treated together. The simple applications of the electronic theory, the use made of the structure of molecules, and the up-to-date information should commend this book to teachers as well as to the class of students for whom it was written. G. FOWLES

Notes on Qualitative Analysis

By H. J. H. Fenton. A new edition, by Dr. B. C. Saunders. Pp. vii+126. (Cambridge: At the University Press, 1953.) 15*s*. net.

THAT many years have passed since this book was revised is a testimony to the worth of Fenton's tables of analysis and to his selection of reagents. Dr. Saunders has put into this edition not only his own experience but also that of his colleagues at Cambridge. He has changed the tables but slightly, adding here and there an alternative separation, and he has inserted a well-chosen selection of modern reagents and procedures. Among these are Holness's effective way of bringing the arsenic group sulphides into solution and both the titanium and the zirconium methods for the removal of phosphate. Apart from this, with the purpose of extending the use of the book to the sixth form of schools, he has made considerable alterations. Gone are the fifty pages on the reactions of organic compounds and in place appears a section on microanalysis. Dr. Saunders has rewritten the notes on theory, he has removed from the analytical tables substances not found in Advanced Level (General Certificate) syllabuses, and

he has added a simple outline plan of the scheme of analysis. The last item is a good teaching aid for it helps a student not to lose his way. The revision has been well done and "Fenton" is now a useful and reliable book for use in schools. G. Fowles

Five-Membered Heterocyclic Compounds with Nitrogen and Sulfur or Nitrogen, Sulfur and Oxygen (except Thiazole)

By L. L. Bambas. (The Chemistry of Heterocyclic Compounds, a Series of Monographs, Vol. 4.) Pp. xi+403. (New York and London: Interscience Publishers, Inc., 1952.) 14 dollars.

THE principal themes of this volume—the fourth of the present series of monographs—are provided by thiadiazoles and *iso*thiazoles. The latter compounds are known only as condensed ring structures as in the benz*iso*thiazoles, whereas the former comprise both monocyclic and condensed cyclic types. These two groups of azoles, together with their selenium analogues, occupy the whole text except for eight pages devoted to representatives of the little-known dithiazoles, dithiadiazoles, thiatriazoles and oxathiazoles. Rational subdivision of each of the main themes allows individual topics to be treated on historical lines, and the author has not hesitated to introduce a controversial note by adding occasionally his own interpretation or point of view. As in earlier volumes of the series the text is profusely illustrated by admirably clear structural formulæ and is supplemented by tables of preparative methods and physical constants for individual compounds: an adequate index is provided. Although current interest in the subject-matter is comparatively slight, the book nevertheless affords an excellent survey of its field and contributes its full share towards the major work of reference of which it forms a part.

J. D. Loudon

L. Farkas Memorial Volume

Editors: Adalbert Farkas and Eugene P. Wigner. (Research Council of Israel: Special Publication No. 1.) Pp. ix+309. (Jerusalem: Universitas Booksellers, 1952.)

THIS volume contains papers by teachers, colleagues, pupils and friends of Ladislaus Farkas, who lost his life in an air accident in 1948. A portrait of him and an appreciation by Sir Eric Rideal appear at the beginning of the volume. There are twenty-four papers by authorities on a variety of subjects, all of which are interesting and useful. Some deal with reaction kinetics, including fast reactions, others with catalysis, adsorption, and enzymes. Farkas was professor of physical chemistry in the Hebrew University of Jerusalem, and all those who recognized the high quality of his work and his great promise must regret that his career was so tragically closed. This volume will serve as a reminder of one who was esteemed by all who met him.

J. R. Partington

Radiation Chemistry

Discussions of the Faraday Society, No. 12. Pp. 319. (Aberdeen: Aberdeen University Press, Ltd., 1952.) 35*s*. net.

THE well-known excellence of the General Discussions of the Faraday Society makes it unnecessary to do more than direct attention to the fact that one on radiation chemistry is available. The papers are fairly short, but they give intelligible accounts of their subjects and the discussions are helpful in that they introduce new material or new aspects of the topics with which they are concerned. What is now called radiation chemistry deals mostly with the effects of X- and γ-rays in inducing chemical reactions. Most of the work is concerned with liquids, both organic liquids and aqueous solutions. Since organisms all contain water or solutions, the subject has a biological aspect. In some cases radiation may bring about polymerization, in other cases it may create free radicals. The exact mechanism is still not always fully understood and differences of opinion exist. The Discussion provides a good and intelligible survey of the subject and will be useful to many classes of reader. J. R. Partington

Physical Chemistry for Colleges

A Course of Instruction based upon the Fundamental Laws of Chemistry. By Prof. E. B. Millard. (International Chemical Series.) Seventh Edition. Pp. ix+618. (London: McGraw-Hill Publishing Co., Ltd., 1953.) 51*s*.

PROF. E. B. MILLARD'S book is probably well known to most teachers of physical chemistry, and it is only necessary to say that the fact that it has reached a seventh edition since it was first published in 1921 is an indication of its excellence. The text has been largely rewritten and rearranged, new material being added when necessary. Problems on topics usually found difficult by students are included. References to original papers have been carefully selected so that students may be encouraged to read at least some of them; many are to American publications, but by no means all. A good feature of the text is the experimental approach; although actual experimental methods and descriptions of apparatus do not appear very prominently, all the fundamental laws are discussed on the basis of numerical results rather than in an abstract or formal way, and most teachers will agree that this is the best way of making their meaning clear to students. It is very likely that individual teachers will vary the order of presentation somewhat; the reviewer thinks the section on thermodynamics (Chapter 18) could well come much earlier in the book, and the electrochemistry is rather condensed. More space is given to equilibrium and phase rule and to kinetics. There is little doubt that this book will continue to be popular, and the care which the author has taken in the revision will be appreciated.

J. R. Partington

Starch and Its Derivatives

By J. A. Radley. Vol. 2. Third edition, revised. (Being Volume Twelve of a Series of Monographs on Applied Chemistry, under the Editorship of Dr. E. Howard Tripp.) Pp. xi+465+35 plates. (London: Chapman and Hall, Ltd., 1953.) 65*s*. net.

THE second volume of Radley's comprehensive treatise on starch and its derivatives deals mainly with industrial aspects, including the manufacture of starch, the production of derivatives and the applications of these materials in adhesives, paper, textiles and foodstuffs. A detailed discussion is given of the methods of analysis available for the assessment of starches and starch products.

The text of many sections is substantially the same as that of the second edition published in 1943, new information being given only in the form of additional references and brief notes. New chapters have been contributed on the manufacture of corn starch (R. W. Kerr), on the production of chemicals from starch by fermentation processes (L. M. Christensen

and L. A. Underkofler), on the role of starch in bread staling (C. W. Bice and W. P. Geddes) and on physical methods for the characterization of starches (C. C. Kesler and W. G. Bechtel). These two volumes bring together in convenient form a mass of carefully documented information concerning the fundamental chemistry and technology of starch and starch derivatives. Like the earlier editions, this one also will be of the greatest value to all concerned with the study or manufacture and use of these materials.

E. L. HIRST

Chemistry of Carbon Compounds

A Modern Comprehensive Treatise. Edited by Dr. E. H. Rodd. Vol. 2, Part A: Alicyclic Compounds. Pp. xxiii+488. (Amsterdam and New York: Elsevier Publishing Co. Inc.; London: Cleaver-Hume Press, Ltd., 1953.) 84*s*.

THIS volume fully maintains the high standard set in Vol. 1 (*Nature*, **170**, 508; 1952). It is, however, more uniform in style, being largely the work of one author, Prof. R. A. Raphael, who has produced an excellent account of the chemistry, including the stereochemistry, of the various alicyclic types from single rings to polynuclear, condensed and bridged-ring systems and spiro compounds. Two short sections, on pyrethrins and hydnocarpic acids, are contributed by Dr. L. Crombie. Carotenoids are dealt with fully in a chapter by Dr. R. H. Hunter, and Dr. R. G. R. Bacon contributes a summary of polymeric derivatives of olefinic compounds, mainly rubber and rubber-like compounds, which are included here since the terpenes are included in Vol. 2*B*.

Like the previous volumes, this provides an authoritative source of accurate, detailed and up-to-date information, and includes numerous references to the original literature and review articles.

C. BUCHANAN

Kinetics and Mechanism

A Study of Homogeneous Chemical Reactions. By Prof. Arthur A. Frost and Prof. Ralph G. Pearson. Pp. vii+343. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 48*s*. net.

THE authors state that there was need of a book giving an adequate account of the relations between kinetics and reaction mechanism, and they have attempted to fill this gap. There is no doubt that the result is satisfactory. It can serve as a text-book for advanced students, a guide to young lecturers, and a reference book which, since it contains bibliographies, will put the reader in touch with the literature. Although many of the examples are chosen from recent publications, the classical investigations, such as those of Harcourt and Esson, are by no means neglected, and it is clear that the authors have read and digested a wide field of literature, not confined to that published in the United States. There is an intelligible account of the transition-state theory, the rather difficult subject of complex reactions is dealt with systematically, and the recent investigations on the mechanism of organic reactions as elucidated by their kinetics are very well covered. Some parts, such as catalysis and chain reactions, are rather briefly considered, but there are other sources available for these. Since the mathematical parts are clearly set out, a student should not have much difficulty in following the text. This is a book which can be recommended.

J. R. PARTINGTON

Changements de phases

Comptes Rendus de la Deuxième Réunion Annuelle tenue en commun avec la Commission de Thermodynamique de l'Union Internationale de Physique, Paris, 2–7 Juin 1952. Pp. ix+487. (Paris: Société de Chimie Physique, 1952.) 3750 francs.

THIS volume contains no fewer than sixty-five papers on various aspects of its subject, and discussions on them. Some of the communications are short, and one consists of only sixteen lines. The subjects are arranged in eleven groups, namely, condensation, critical phenomena, phase equilibrium in solutions, solutions of polymers and colloids, co-operative phenomena in solids, polymorphism and rotation transitions, kinetics in solids, ferromagnetism and lambda-points, fusion, transitions in amorphous bodies, and transitions in surface phases. The papers are accompanied by short bibliographies. The collection will no doubt be very useful to those working in the field; but the treatment is, in general, too condensed to be easily understood by others, and it might have been better to have dealt with a more restricted field and to have had fewer papers. It would also have been useful to have included summarizing papers for each group, so that the general results of the work could be ascertained. The lack of agreement disclosed in the discussions is also confusing to those not actually working in this field. The discussion was probably of value to the participants; but the general reader may wish for a more homogeneous and critical survey of the important subject than is presented here.

J. R. PARTINGTON

Data for X-Ray Analysis

(Philips' Technical Library.) Vol. 1: Charts for Solution of Bragg's Equation (d versus θ and 2θ). By W. Parrish and B. W. Irwin. Pp. vii+100. Vol. 2: Tables for Computing the Lattice Constant of Cubic Crystals. By W. Parrish, M. G. Ekstein, and B. W. Irwin. Pp. vii+81. (Eindhoven: N.V. Philips Gloeilampenfabrieken; London: Cleaver-Hume Press, Ltd., 1953.) 15*s*. each.

VOL. 1 contains graphs of lattice spacing against Bragg angle, covering a range from about 85° down to low angles corresponding to spacings of 21 A., for chromium, iron, cobalt and copper $K\alpha$ radiations; the high angle limit is 40·5° for molybdenum. Spacings may be read to 0·01 A. at low angles and, due to a change in scale, to 0·001 A. at high angles, the $K\alpha_1$ and $K\alpha_2$ curves being plotted separately beyond a Bragg angle of 21°. The charts are intended for rapid determinations of lattice spacings in routine powder analysis, and they are admirably suited for this purpose. A still more open scale for lattice spacing might, however, have been used with some advantage at the very high angles, where the slope of the curves is sometimes as little as one part in forty.

The bulk of Vol. 2 consists of tables of $\frac{\lambda\sqrt{h^2+k^2+l^2}}{2}$ for the $K\alpha_1$, $K\alpha_2$ and $K\beta_1$ radiations of copper, nickel, cobalt, iron and chromium. The tables will shorten considerably the labour of calculating cubic lattice parameters, and, as they are given to six decimal places, they are suitable for work requiring high accuracy. Tables of $\sin^2\theta$ and of the Nelson and Riley function $\frac{1}{2}\left(\frac{\cos^2\theta}{\theta}+\frac{\cos^2\theta}{\sin\theta}\right)$ are useful additions to the volume. A table of lattice constants of cubic

substances, due to Frevel, may be somewhat misleading as it is by no means complete. For example, although the β-brass and related structures are listed, the complex γ-structures in alloys are omitted as also are the α- and β-manganese structures.

I. G. Edmunds

Crystal Structures

By Ralph W. G. Wyckoff. Vol. 3. Pp. xi+641. 14.50 dollars. Second Supplement. (Supplement to Chapter 13.) Pp. 148. 4.00 dollars. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1953.)

THE appearance of Vol. 3 of this work marks the end of the first stage of the task which Dr. Wyckoff has set himself—the presentation of the whole of the results of crystal-structure determination. The two previous volumes (see *Nature*, **169**, 681; 1952) were concerned with inorganic and some organic structures; the present volume is confined to organic structures, and, with the addition of the earlier organic section (Chapter 13), provides a complete review of organic structures up to about the middle of 1952.

The loose-leaf form of publication makes the removal of chapters in this way quite possible, and also allows the introduction of supplements, one of which is published together with Vol. 3. This supplement brings up to date some of the information in Vol. 2, and two more Chapters, 11 and 12, remain to be included.

The results are clearly set out, with brief descriptions of the various structures, tables of atomic parameters, drawings, and references. The drawings are of two types—schematic ones, showing the heights of the atoms above a reference plane, and perspective ones, showing the packing of the atoms, which are represented as shaded spheres. These latter drawings are often very beautiful; but it is questionable whether the information they provide justifies the work of preparing them; the more complicated molecules look quite bewildering.

It is a pity that the price of the book is so high. In particular, the supplement, consisting of relatively few pages without any binding, is very costly.

The Measurement of Particle Size in Very Fine Powders

Four Lectures delivered at King's College, London. By Dr. H. E. Rose. Pp. 127. (London: Constable and Co., Ltd., 1953.) 9*s*. net.

THREE properties, which Dr. Rose terms primary characteristics, are of importance in many industrially significant dusts and powders; they are size frequency, specific surface and particle shape. In his lectures Dr. Rose is concerned mainly with the determination of particle size and size frequency and subordinately with specific surface. He refers to most of the techniques available for particle-size determination in powders within the size range 1 to 60 microns and discusses simply, but adequately, the theoretical principles of the various techniques and their practical application and limitations. The photo-extinction method, in which Dr. Rose is particularly interested, receives, rather naturally, more detailed treatment than other methods. He refers, also, to some of his own research work.

The lectures are interestingly written; the illustrations are clear; the equations are easy to read; and the whole forms a satisfying small book which should prove valuable not only to those with experience in this field but also to newcomers, especially in helping to solve the problem of selection of the best method of particle-size determination for a particular powder or dust.

Stacey G. Ward

Physical Formulae

By Dr. T. S. E. Thomas. (Methuen's Monographs on Physical Subjects.) Pp. vii+118. (London: Methuen and Co., Ltd.; New York: John Wiley and Sons, Inc., 1953.) 8*s*. 6*d*. net.

DR. THOMAS'S little book contains many of the more important results in statistics and classical physics. The chief criticism is that it is out of place in a series intended to supply science students at university-level with a compact statement of the modern position in each subject; and that it would have been entirely in keeping with this intention if it had dealt equally generously with modern physics.

G. R. Noakes

Mechanics

(Lectures on Theoretical Physics, Vol. 1.) By Arnold Sommerfeld. Translated from the fourth German edition by Martin O. Stern. Pp. xiv+289. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1952.) 6.50 dollars.

THE appearance of this English translation makes a valuable addition to the books now available to introduce students to mechanics as a live subject. The contents of this volume have already been discussed in a review of the German edition (*Nature*, **168**, 887; 1951); but it is worth stressing again the value of this introduction as a counter-weight to the tendency, so widespread in the teaching, particularly in English schools, of regarding mechanics merely as a branch of mathematics. The lively and readable style of the book has not been lost in translation. The book covers the contents of a normal university course in mechanics. The numerous examples with aids to their solution are all designed to bring home important points of principle, and none of them is of the 'ladder leaning against a wall' type, which is more suited to traditional examination papers than to develop an understanding of the subject.

This book, like the others in the same series, will help to make available to the prospective theoretical physicist the insight and the experience of one of the most successful and inspiring teachers.

R. E. Peierls

Principles of Modern Acoustics

By Prof. George W. Swenson, Jr. Pp. vii+222. (New York: D. Van Nostrand Company, Inc.; London: Macmillan and Co., Ltd., 1953.) 30*s*. net.

IN this book the subject of acoustics is considered as the study of inter-related electrical, mechanical and acoustical systems as applied to the production and reproduction of sound, and, as may be expected, great use is made of analogies, especially in the discussion on electroacoustics.

For a thorough study of the analysis and description of acoustical phenomena it is, as the author quite rightly recognizes, very necessary to approach the problem from the mathematical angle. This is what is done in this book, and for those students who can think, reason and understand in terms of mathematical equations and deductions it will be helpful, for the author starts from first principles and his exposition is clear. It is not the book, however, for those students who require a general description of acoustical phenomena and devices and who are

satisfied with simply expressed explanations without the backing of mathematical theory.

In view of the space at his disposal the author has wisely decided to confine himself to the general methods of analysis, illustrated by application to a few typical devices.

A list of standard treatises on acoustics, mechanics and electricity is given in the many footnotes, and these should be of great service to those students who wish to pursue the study of particular topics to a further stage. T. M. YARWOOD

Methods of Mathematical Physics

Vol. 1. By R. Courant and D. Hilbert. (First English edition translated and revised from the German Original.) Pp. xv+561. (New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1953.) 9.50 dollars.

ENGLISH translations of standard German books are always welcome, and in view of the current demand for mathematics in scientific and technical applications it is particularly pleasing to have this translation. The original text was reviewed at length in *Nature* (153, 633; 1944) by Prof. Milne-Thomson, and readers are referred to this for details concerning the present volume. For the translation, it is sufficient to say that there are numerous additions and modifications, the most extensive of which is an appendix (to Chapter 7) by Wilhelm Magnus. This concerns the transformation of spherical harmonics. A pleasing feature is that the bibliography has been brought up to date. The printing is excellent.

L. S. GODDARD

Electrostatique et Magnétostatique

Par Émile Durand. Pp. xii+774. (Paris: Masson et Cie., 1953.) 6335 francs.

THIS work is an uneasy compromise between a text-book and a reference book. Students who like spoon-feeding will be delighted by the author's painstaking elaboration of the subject and discussion of many examples in which all calculations are given to the last detail. Experimental physicists and engineers will find in it a wealth of up-to-date information about the mathematical basis of the most varied applications of the electrostatic and magnetostatic fields. But one should not look in it for a deeper treatment of the fundamentals of the subject.

Within these limitations this book will certainly be very useful and can be warmly recommended. It is, of course, difficult to be original in treating such a classical subject, and the author's exposition follows the traditional lines. Nevertheless there are a few happy innovations. The Giorgi system of units is consistently used and many tables of typical constants are given, probably for the first time, in these rational units. An interesting chapter describes in a very practical spirit the numerical methods of calculation of field distributions. The treatment of the magnetic properties of matter, and especially that of ferromagnetism (a domain to which the French school has made a brilliant contribution), is particularly well done.

Although the exposition is generally clear, the style is rather pedestrian and there is no sparkle in the book of that elegance which used to be characteristic of the French scientific tradition. It was a shock to discover that the author is so estranged from this tradition that he barbarously denotes the tartrate rendered famous by Pasteur as "sel de Rochelle". L. ROSENFELD

Radioactivity and Radioactive Substances

By Sir James Chadwick. Fourth edition. Pp. xv+120. (London: Sir Isaac Pitman and Sons, Ltd., 1953.) 12*s*. 6*d*. net.

THIS text-book has stood the test of time and in spite of the remarkable developments in the field of nuclear physics during the past fifteen years it still remains one of the best introductions to the fundamentals of the subject. It was first published in 1921 and has now reached the fourth edition. The arrangement of the material in the new edition is substantially the same as that in the original edition; but where necessary the subject-matter and data have been modified or supplemented to bring it up to date. In the chapter on measurements more modern methods and techniques have been introduced and a new chapter on nuclear structure, in which nuclear stability, artificial radioactivity and nuclear fission are discussed, has been added. These revisions and additions are by Prof. J. Rotblat, who it will be remembered worked for many years at Liverpool under Sir James Chadwick and who is thus well qualified to revise a book originally written by Sir James. S. WEINTROUB

Optics

The Technique of Definition. By Arthur Cox. Tenth edition. Pp. 376. (London and New York: The Focal Press, 1953.) 17*s*. 6*d*. net.

IF the popularity of a book can be judged by the number of editions published, then this book must indeed be very popular, for it now appears in its tenth edition, the first having been published in 1943.

The work is devoted entirely to what are undoubtedly the most precious and vital parts of any camera, namely, lenses, and the subject is treated very exhaustively and thoroughly, in a language which the ordinary photographer can understand without becoming involved in scientific formulæ.

The full study of lenses is admittedly highly technical; but the treatment here is so skilfully done that the reader cannot fail to become intensely interested, and he soon finds himself able to understand how his lens works and why, what may be expected of it and what is the best type to use. The gap between the scientific approach of the designer and the practical man who uses the lens has been bridged, and the photographer can now have an added zest and intelligence for his work, based on a more intimate knowledge of his chief tool.

It is not only the photographer who can derive benefit from the book. There are also excellent articles on the defects of lenses, such as aberrations of various types, distortion, etc., which will be found useful to any student of optics whether interested in photography or not. T. M. YARWOOD

Advances in Applied Mechanics

Edited by Richard von Mises and Theodore von Kármán. Vol. 3. Pp. x+324. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1953.) 9 dollars.

THIS third volume carries on the admirable tradition already established. The present book is almost entirely devoted to problems of fluid dynamics except for a long, careful, interesting and important article by Dr. Geiringer giving a very comprehensive account of some recent results in the theory of an ideal plastic body. There is also a short

article by Albert I. Bellin on recent work on non-linear differential equations of the second order.

G. F. Carrier gives an account of some boundary layer problems in oceanography, in heat transfer and in electrical relaxation oscillations. Zaldastani describes recent work which extends and generalizes the classical researches of Riemann on one-dimensional isotropic fluid flow. The problem of diffusion through a field of homogeneous turbulence is studied by F. N. Frenkiel. H. F. Ludloff deals with the aerodynamics of blasts and G. Guderley with the presence of shocks in mixed subsonic–supersonic flow patterns. A short and useful article by L. Rosenhead gives a critical summary of most of the theoretical and experimental papers which have been written about wakes for Reynolds numbers less than 2500.

There is no doubt that this series of reports has become indispensable to research workers in applied mechanics. Perhaps it is not out of place to take this opportunity of recording the gratitude which all readers must feel to one of the editors, Prof. Richard von Mises, who died a short time ago, and to whose scholarship and vision we owe so much.

G. Temple

The Great Palomar Telescope

By Helen Wright. Pp. 176+15 plates. (London: Faber and Faber, Ltd., 1953.) 12*s*. 6*d*. net.

As an astronomer's account of the 200-in. telescope, written for the general reader, Miss Helen Wright's book is very satisfying. The instrument and its observatory are described fully, with many photographs and line drawings. There is an introductory chapter on the evolution of the telescope and the spectroscope, and an outline of the progress which had been made with the aid of the Mount Wilson 100-in. reflector up to about 1936. It is a book one would recommend strongly for inclusion in, say, a school library; and it would certainly be appreciated by the young science student.

Miss Wright writes with a lively journalistic manner. Except during the hiatus of the war years, indeed, the progress of the telescope was news, often quite exciting news. The atmosphere of mounting public interest is recaptured here, for reporting was immediate and full. The technical problems that were faced are described clearly in less vivid terms. Dr. G. E. Hale, who lived to see the major difficulties surmounted but not the completion of the work, is the central character of the story. But the adventures of the telescope itself, starting with the financial crisis of 1929, beset by floods at the Corning Works during annealing, pursued during the last journey to the observatory by hazards of ice and blizzard, speak of the effort and determination contributed by all engaged in the work. The author's treatment of the human side of the enterprise adds greatly to one's enjoyment of the book.

G. R. Noakes

Linear Algebra and Projective Geometry

By Reinhold Baer. (Pure and Applied Mathematics Series, Vol. 2.) Pp. viii+318. (New York: Academic Press, Inc.; London: Academic Books, Ltd., 1952.) 6.50 dollars.

Twentieth-century mathematics shows a change of trend away from the details of particular theorems towards abstraction and the analysis of structure. The object of the book under review is to prove the essential structural identity of projective geometry and linear algebra. The author has gathered together much material difficult of access elsewhere and supplemented it by his own researches. To a geometer of the older type the result is by no means easy reading. He will find little or no opportunity to use his geometric intuition; but a constant need for a good grasp of the concepts of abstract algebra. He may imagine that the author's object is not so much to prove the equality of projective geometry and linear algebra as to reduce the former to a satellite of the latter. However, to those who accept the abstract point of view the book has many merits. It deals with the representation of projective geometries by linear manifolds, of projectivities by semi-linear transformations, of collineations by linear transformations, and of dualities by semi-bilinear forms. Thus the geometry with which the discussion starts is reconstructed within such apparently purely algebraic structures as the endomorphism ring of the underlying linear manifold or the full linear group. The book contains seven chapters, and concludes with an appendix on the theory of sets, a bibliography, and an index.

H. T. H. Piaggio

Pages choisies d'analyse générale

Par Maurice Fréchet. (Collection de logique mathématique, Série A, No. 3.) Pp. 214. (Paris: Libr. Gauthier-Villars; Louvain: E. Nauwelaerts, 1953.) 2000 francs.

'General analysis' is usually associated with the name of the American Prof. E. H. Moore, whose researches began in 1906, but actually those of Prof. M. Fréchet began two years earlier. Both sought to generalize the classical theory of functions of real variables and Cantor's theory of sets, but Moore was influenced by algebra and integral equations, while Fréchet was influenced by geometry. For several years these two authors developed the subject on somewhat different lines; Moore pointed out that Fréchet's approach was more abstract and more general than his own. Prof. Fréchet intended to write a book on general analysis as a sequel to his book on abstract spaces, but his appointment as professor of the calculus of probabilities diverted his interests. Now, after many years, he has been persuaded to collect and republish the most important of his papers on general analysis, some of which, scattered among the periodicals of several countries, had become almost inaccessible. The papers have been arranged in logical (not chronological) order, sometimes shortened, and grouped into chapters, supplemented by references to later developments by other authors. This has produced something very much like the book for which his friends and pupils had waited so long. The first chapter gives a general outline of the subject, the second deals with functional spaces, and the third with functional analysis. The fourth chapter introduces abstract spaces; the fifth and last, general analysis.

H. T. H. Piaggio

Foundations of Algebraic Topology

By Samuel Eilenberg and Norman Steenrod. (Princeton Mathematical Series.) Pp. xv+328. (Princeton, N.J.: Princeton University Press; London: Oxford University Press, 1952.) 48*s*. net.

This book presents, for the first time, an axiomatic treatment of the complete transition from topology to algebra. Chapter 1 gives the axioms for a homology theory, and a set of general theorems deducible from them. Chapter 2 deals with simplicial complexes and triangulable spaces. In Chapter 3, a

homology theory is assumed given on triangulable spaces; the classical algorithms for computing the homology groups of a complex are then derived from the axioms, and using these, the axioms are shown to be categorical for homology theories on triangulable spaces.

Chapter 4 presents the concepts of category and functor. Chapter 5 makes the step from chain complexes to homology groups. Chapter 6 gives the classical homology theory of simplicial complexes, while in Chapter 7 the singular homology theory is defined and shown to satisfy the axioms. In Chapter 8, direct and inverse systems of groups and their limit groups are considered, as an algebraic preliminary to the development of the Čech homology theory given in Chapter 9; additional properties of the latter are set out in Chapter 10, where it is seen that the addition of a single new axiom characterizes the Čech theory on compact spaces. Two additional homology theories are constructed which are extensions of the Čech theory on compact spaces.

Chapter 11 gives classical applications of homology theory, including the Brouwer fixed-point theorem, invariance of domain, and the fundamental theorem of algebra. The authors state that a second volume is in preparation. The book is excellently written from the axiomatic point of view. R. G. COOKE

Description of a Magnetic Drum Calculator

By the Staff of the Computation Laboratory. (Annals of the Computation Laboratory of Harvard University, Vol. 25.) Pp. xi+318. (Cambridge, Mass.: Harvard University Press; London: Oxford University Press, 1952.) 52*s*. net.

THE publication of complete design information about a large automatic computing machine is something of a problem, partly because of the speed at which the subject has developed in the past decade and partly because of the magnitude of the task. As a result all too few computers are as fully documented as those designed and built at the Harvard Computation Laboratory. Four Harvard machines are now in existence. Mark I, also known as the Automatic Sequence Controlled Calculator, was completed in 1944 and is still in use at the Laboratory. Mark II was completed in 1948 and has since been in operation at the U.S. Naval Proving Ground, Dahlgren, Virginia. Mark III, which forms the subject of this volume, was the first of the series to make use of electronic techniques; it began to operate on a production basis at Dahlgren in 1951. Since that time development has continued and a further machine, Mark IV, has been built and is now working at Harvard.

Much of the logical design of Mark III matches the distinctive pattern established by its two predecessors. The decimal scale is used, and numbers are stored quite separately from instructions. This was one of the earliest machines to employ magnetic drums for internal storage and to exploit the possibilities of magnetic tape as an input/output medium. The nine drums were carefully engineered and use a rather conservative pulse density. A certain amount of checking equipment is built into the machine, which uses a word length of sixteen decimal digits.

Most of this book is devoted to details of the logical design, engineering and circuits of the machine. These are very fully covered and well illustrated. A description of how problems are prepared and presented to the computer is also given, together with some simple examples. E. N. MUTCH

Typical Means

By Prof. K. Chandrasekharan and Prof. S. Minakshisundaram. (Tata Institute of Fundamental Research Monographs on Mathematics and Physics, 1.) (Published for the Tata Institute of Fundamental Research, Bombay.) Pp. xi+140. (London: Oxford University Press, 1952.) 35*s*. net.

OF the numerous methods devised for dealing with oscillatory series, one of the most important is by the use of M. Riesz's 'typical means'. The first systematic account of what Prof. G. H. Hardy described as "his beautiful theory" appeared in Hardy and Riesz's Cambridge Tract "The General Theory of Dirichlet's Series" in 1915. Since that time the subject has developed considerably. The book under review gives a comprehensive account, including a good deal of material hitherto available only in research periodicals and even some still unpublished when the book appeared. The first and second chapters deal with the general theory, including theorems of consistency and Tauberian theorems. The third chapter applies this theory to Dirichlet's series. The fourth chapter applies it to Fourier series, starting with a theorem due to S. Bochner on multiple Fourier series and including several results due to Prof. Chandrasekharan himself. A valuable feature of the book is the supplementing of each chapter by extensive bibliographical notes.

H. T. H. PIAGGIO

Stochastic Processes

By Prof. J. L. Doob. (Wiley Publications in Statistics.) Pp. vii+654. (New York: John Wiley and Sons, Inc.; London: Chapman and Hall, Ltd., 1953.) 80*s*. net.

THIS text is important for at least two reasons. It meets a long-felt need for a systematic account of a subject which has grown rapidly during the past 20–30 years; and it is an account in English of a subject which has developed largely outside the English-speaking world. Readers for whom the Russian language is a closed medium will find here accounts of contributions by Gnedenko, Khintchine, Kolmogorov, Krein and other Russian authors.

There is an introductory chapter on elementary definitions and theorems in probability theory, but, as Prof. Doob points out, "there has been no compromise ... probability is simply a branch of measure theory ... and no attempt has been made to sugar-coat this fact". This attitude, indeed, sets the flavour. The reader who is not a specialist in measure theory will find the going heavy in places, but he may be consoled by the fact that there is a supplement on measure theory. After three chapters dealing with stochastic processes in general there come two chapters on Markov processes. In the first of these there is a lucid account of finite-dimensional Markov chains with an application to card shuffling. In the second there are applications to diffusion equations, including the Fokker–Planck equation occurring in various physical problems. Next comes a long chapter on martingales with an application to games of chance. Later, there are chapters on stationary processes, and the book ends with a chapter on linear least-squares prediction.

It is perhaps worth emphasizing that the present work is mathematical rather than applied in character, in the sense that mathematical formulation and method take precedence over the details of applications. L. S. GODDARD

Sampling Methods for Censuses and Surveys

By Frank Yates. Second edition, revised and enlarged. Pp. xvi+401. (London: Charles Griffin and Co., Ltd., 1953.) 38*s*. net.

THIS book, first reviewed in *Nature* (**166**, 245; 1950), has an established place as an authoritative manual on the general subject of sampling. The author now has more to say, sometimes by way of commentary on or expansion of what was in the first edition, but mostly by way of new material and developments. He has chosen to leave the eight chapters of the first edition unaltered, except for the insertion of references to the added material, and to add two new chapters. Chapter 9 consists of a series of further notes on the critical analysis of survey data. Broadly, these deal with general questions such as contrasts between domains, or the relative precision of different methods of sampling, especially when domains of study cut across strata; but the opportunity is taken to supplement an earlier treatment of simple regression by describing briefly the multiple regression procedure, and by showing how this concept is to be interpreted in terms of causative systems. Chapter 10 deals with a number of miscellaneous developments. Modern machines for use in computation and census work are referred to, but so briefly that legitimate curiosity is not satisfied; most of the remainder concerns varied methods of sampling, of which lattice sampling may be singled out as an ingenious way of incorporating the same sort of advantages into sampling that are gained by designing agricultural and other experiments on such patterns. The book is brought up to date by a description of the sampling method used for speeding up the reporting of the results of the 1951 Census.

The author is to be commended on his industry in coping with a very intricate subject in such painstaking detail. The result, however, is a book that is by no means a delight to read, for the style is heavy and, in places, obscure. A most complicated notation means that the reader must not allow his attention to wander. For his sake it is a pity that the author has at times forgotten the rigours of his own notation, for example, on p. 298 in quoting a formula in words in the text, while he might have avoided adding to the confusion by using the first two letters of the alphabet in different senses in the same formulæ, as he does on pp. 318–19. J. Wishart

Cambridge Elementary Statistical Tables

By D. V. Lindley and J. C. P. Miller. Pp. 36. (Cambridge: At the University Press, 1953.) 5*s*. net.

THE statistical material in this set of tables consists of the normal, t, χ^2 and variance ratio distributions, the r–z transformation, factors for converting range to standard deviation, and random numbers, occupying in all ten pages. The remaining twenty-two pages are taken up by tabulations of x^2, $\sqrt{x}$, $1/x$, $1/\sqrt{x}$, $\log x$, antilog x, $\sin^{-1}\sqrt{x}$, $\sinh^{-1}\sqrt{x}$, $\log n!$ and a one-page table of proportional parts from 2–99 (surely unnecessary).

The printing, binding and layout reach that high standard which one would expect from collaboration between the authors and the Cambridge University Press, and the price is such that the tables should, as the authors hope, be useful for students in schools and universities, and for the research worker who requires a handy set of tables for the occasional normal, t, χ^2 or F test. But one could have wished that the statistical material had been treated a little more generously to the exclusion of material adequately covered by ordinary four-figure mathematical tables. Fisher's original tables of t and χ^2 covered the whole range of P, and z has since been extended in a similar manner. The central values have their uses, both for the student and research worker. The table of percentage points of the normal distribution might well be fuller, and possibly that of the ordinates also, and one misses a table of significance levels of r, which gives a quick test of association between two variates. Random permutations also have a claim to inclusion. The preface is confused on the relation between one- and two-tail tests, and this, perhaps, has led to a rather curious choice of significance levels. Finally, the reviewer, at least, is left wondering why the non-statistical functions are all presented together instead of separately on pairs of pages.

F. Yates

The First Fifty Years, 1903–1953

Edited by F. I. G. Rawlins. Pp. xv+86+11 plates. (London: The Faraday Society, 1953.) Cloth 10*s*. 6*d*.; Leather 21*s*.

"THIS little book is not a set piece; it is more in the nature of a birthday book in which people have been good enough to write interesting things about the Society, now on the threshold of its fiftieth anniversary"; in these words, the editor, Mr. F. I. G. Rawlins, describes the purpose of the volume under review.

The Faraday Society occupies a unique position in the chemical world; it has fostered the study of physical chemistry in all its branches, first, by providing, in its *Transactions*, a medium for the publication of physico-chemical research, and secondly, and perhaps this has been its most important, as it has certainly been its unique, contribution, by organizing the famous 'General Discussions'. These symposia on current topics have been characterized by timeliness, and few of them have not been followed by a real reorientation of thinking on the subject under discussion. In addition, these discussion meetings have been notable social occasions; the editor says that he and the other contributors to the present volume have been "trying to enjoy ourselves"—not a difficult task for regular attenders of the Society's discussions.

It is most fitting that the first article in the book is a chapter of personal reminiscences by Prof. F. G. Donnan, since he has probably done more than any other single man to guide the Society along the right paths during its first fifty fruitful years; the other thirteen chapters give the reader a valuable and interesting bird's-eye view of the development of physical chemistry between 1903 and 1953. Mr. Rawlins need have no doubt that this book does indeed "demonstrate that the Faraday Society is a living organism, continually emitting and receiving new knowledge on its way towards equifinality"; long may it remain so. H. N. Rydon

The Art of Scientific Investigation

By Prof. W. I. B. Beveridge. Second Edition. Pp. xii+176+5 plates. (London: William Heinemann, Ltd., 1953.) 10*s*. 6*d*. net.

PROF. BEVERIDGE, in preparing the second edition of his book on the methods and results of scientific investigation, has made some minor revisions and partly re-written the chapter on reason. Essentially, however, the book remains as reviewed in our columns on March 3, 1951. A. S. Parkes

INSTRUCTIONAL FILM RESEARCH IN PENNSYLVANIA

ACCOUNTS of the early reports of the Pennsylvania Instructional Film Research Program have already been given in *Nature*[1,2], and it is the purpose of this article to review shortly some further Pennsylvania reports* now available in Great Britain. In every Pennsylvania experiment in which the learning results have been objectively assessed, people have learned from the films shown them[3]. Many of these further studies confirm that films can teach effectively, and though this, in fact, is usually discovered incidentally, it is sometimes borne out as the result of the main purpose of an experiment, as in Study 29, which deals with the instructional effect of the film "How to Operate the 16-mm. Sound Projector Set".

Learning from films may be factual learning or motor perceptual learning. A group of the new Studies, 25–27, by S. F. Harby, is concerned with the use of film-loops, daylight projected, for the teaching of athletic skills. The film-loop demonstrations were as effective as live instructor demonstrations, the addition of physical practice and coaching to the film-loop demonstrations being advantageous. A directed system of watching the film-loops and of practice was better than leaving the students with no outside guidance.

Mental practice, defined as the symbolic or covert practice of a perceptual-motor skill and described as resulting from trying to "imagine the feel of it", is—according to M. A. May[4]—an ingredient in any film-learning situation. Study 26 compares the effectiveness of mental and physical practice. There is a point beyond which mental practice does not help. Twenty periods of physical practice were significantly more effective than twenty periods of mental practice. Films extend the time learners can and will practise mentally.

A number of earlier findings of the Pennsylvania research are confirmed by the new studies: repeated showings of a film can result in a worth-while increase in learning (Studies 29 and 25–27); increased experience of films in training improves the ability of an audience to learn from films (Study 20, by A. W. Vander Meer); and note-taking during the showing of films interferes with learning (Study 21, by Ash and Carlton, and also independently reported[5]).

As in all learning situations, the student who is to learn from films must wish to learn and perceive relevance in what is put before him. A number of the new studies deal with the motivation of the student towards learning, with his participation and involvement, and Study 24 shows that anxiety—fear of the consequences of failing in a test of knowledge gained from a film—leads to increased learning. The advantages of a pre-film test of performance and of factual knowledge are shown by Studies 29 and 35, and of providing the correct answers to all test-questions—rather than merely informing a student that he is right or wrong—by Study 30. Study 33 shows that written titles making plain the 'organizational outline' of a film increase learning, particularly for the less intelligent.

A further comparison of black-and-white and colour films (Study 28) shows that colour makes a contribution to retention of what is learnt rather than to learning itself, but this contribution does not seem to be large enough to justify the additional cost of coloured films. The single Study (32) so far carried out on stereoscopic films shows no advantage in stereoscopy.

Study 23, "Film Profiles", by Loran Twyford, in examining the value of subjective evidence, has some general psychological interest and is also of interest because it may lead to a change in the method of film investigations. The popularity of a radio programme has often been assessed by what is called 'a rating profile', a profile based on polygraph recordings of the responses of a sample audience, peaks in the profile representing sections of the programme to which a large number of the audience respond positively. Would the rating of an instructional film based on positive responses 'I am learning' and negative responses 'I am not learning' be a valid rating of learning? It was found in the Pennsylvania experiments that the subjectively based profile was, in fact, correlated highly with an 'objective test' profile, and in another film investigation, outside Pennsylvania, the subjective judgment of an audience has appeared similarly valid[6].

Report 31, by the director of the Pennsylvania research, is largely a more positive statement of principles previously put forward as "trends of results"[7]. In general, the sixteen studies reviewed confirm and refine earlier results, although a first experiment on stereoscopic films has been made, and a fresh finding may lead to a change in the method of film investigations.

C. DENIS PEGGE

* Technical Reports S.D.C. 269-7-20 to S.D.C. 269-7-35 of The Instructional Film Research Program, The Pennsylvania State University, U.S.A.

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REDUCTION BY X- AND γ-RAYS OF SOME SUBSTANCES OF BIOLOGICAL INTEREST

By DR. GABRIEL STEIN*
and
DR. A. J. SWALLOW†
Department of Radiotherapeutics, University of Cambridge

IT is usually considered that the main primary effect of ionizing radiations on aqueous solutions is to form hydrogen atoms and hydroxyl radicals[1]. In the presence of a solute which can be oxidized in two steps, the hydroxyl radicals may react according to:

$$AH_2 + OH \rightarrow AH + H_2O. \qquad (1)$$

We wish to present a number of instances where a second solute is introduced in a concentration so small that the AH_2 protects it from hydroxyl radicals, and the effects observed on the second solute must be due to the action of AH radicals or hydrogen atoms, or both.

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Sources of radiation included cobalt-60 γ-rays, 220 kV_p. X-rays filtered through 1 mm. aluminium, and unfiltered 200 and 190 kVp. X-rays. Dose-rates with γ-rays were 7–12 r./min. and with X-rays 500–3,000 r./min. Doses were of the order of 30,000 r. Temperatures were 20–40° C.

Methylene blue. In air-free solutions in the absence of other organic solutes, the decoloration of methylene blue (10^{-5} *M*) by X-rays is partly a reversible reduction and partly an irreversible oxidation[2]. Addition of 0·5 *M* sodium benzoate results in an increased rate of decoloration, which is now entirely due to a reversible reduction. The addition of ethanol has a similar effect[3].

In the presence of dissolved air, the reversible reduction cannot be demonstrated, and the irreversible oxidation can be prevented by sodium benzoate, which in this case is acting as a protective agent in the sense employed by Dale[4].

Coenzyme 1. The irradiation with γ-rays of air-free aqueous solutions of coenzyme 1 (3×10^{-4} *M*, *p*H 7·8) in the presence of 0·5 *M* ethanol results in a yield of acetaldehyde three times greater than in the absence of coenzyme 1, and a substance with an absorption band at 340 mμ is formed[5]. This substance is also formed with X-rays at both *p*H 7·8 and 10·4, and tests with lactic dehydrogenase have shown that it is not identical with coenzyme 1 reduced enzymatically, and also it does not exhibit the characteristic whitish fluorescence of this compound. The irradiation product resembles the enzymatic product in that further irradiation changes the absorption curve in the same way, both substances slowly reduce methylene blue, and both absorption curves shift in the same way on addition of acid[6]. It may be that the irradiation product is identical with one of the substances made by reducing coenzyme 1 with sodium borohydride[7]. The irradiation product appears in the presence of 0·5 or 0·01 *M* β-hydroxybutyrate, *n*-propanol, *iso*-propanol or allyl alcohol. It is produced in 0·01 *M* but not 0·5 *M* solutions of lactate. No product appears at either concentration in solutions of benzoate, succinate, glucose or maleate[8]. None of the product appears in air-free solutions of coenzyme 1 alone or when hydrogen is present. In the presence of dissolved oxygen, the product could not be observed in the presence of any added substance.

Nicotinamide-methochloride. In order to obtain further information about the nature of the irradiation product of coenzyme 1, we have irradiated aqueous solutions of nicotinamide-methochloride with X-rays, and have found that in the presence of ethanol its radiation chemistry is similar to that of coenzyme 1[6]. The irradiation product (which absorbs at about 360 mμ in this case) has been extracted from the irradiated solution and found to have an absorption spectrum different from that of Karrer's N-methyl-*o*-dihydronicotinamide[9]; but it changes in the same way on addition of acid (Fig. 1). The product has a much weaker fluorescence than Karrer's N-methyl-*o*-dihydronicotinamide; it reduces silver nitrate instantaneously in the cold and decolorizes methylene blue at the same rate as Karrer's substance. The product does not appear when pure nicotinamide-methochloride solutions are irradiated in the presence of molecular hydrogen, or when pure solutions are irradiated in the absence of oxygen. In the presence of dissolved oxygen, the product does not appear whether ethanol is present or not.

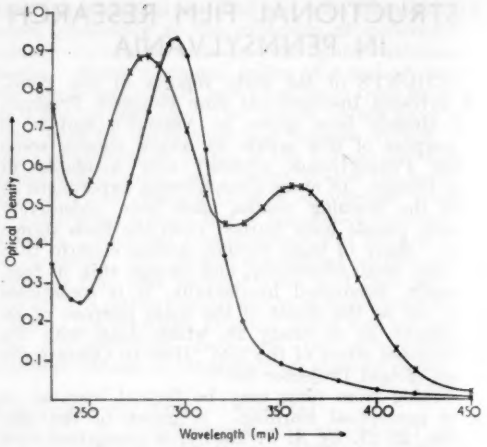

Fig. 1. Irradiation of nicotinamide-methochloride. Absorption curve of irradiation product (0·03 mgm./ml.). ×—×, *p*H 11·0; ●—●, after acidification

The structure of the irradiation product is not yet certain, but there are three positions in the pyridine ring at which reduction is possible[9]. Karrer's N-methyl-*o*-dihydronicotinamide corresponds to one of the positions, and this is also the position at which reduction takes place when coenzyme 1 is reduced enzymatically. Karrer *et al.* have also prepared an N-methyl-dihydronicotinamide, which is stable to the addition of acid, and this corresponds to reduction at a second position[9]. It seems possible that our product has been reduced at the third position.

Cytochrome c. The irradiation with X-rays of cytochrome *c* (10^{-5} *M*) in air-free solutions containing 0·5 *M* benzoate or succinate leads to a product which exhibits the typical absorption spectrum of reduced cytochrome *c*. The product can be reoxidized by ferricyanide, and it reacts with the complete enzyme system of heart-muscle preparation, as does reduced cytochrome *c* which has been produced by, for example, hydrosulphite. If, however, methanol, ethanol, *n*-butanol or dissolved molecular hydrogen are used instead of benzoate or succinate, the irradiated solution contains a reduced product which can be oxidized with ferricyanide; but both irradiated and reoxidized solutions have an absorption spectrum different from normal cytochrome *c* (Fig. 2)[10]. This latter spectrum is also obtained in a lower yield in air-free solutions containing cytochrome *c* alone.

The results given above show that organic additions do not all result in the same reactions on irradiation. This indicates that specific differences exist in the behaviour of the organic *A*H radicals, in broad agreement with the conclusions drawn by Mackinnon and Waters[11].

The absence of any reduction in the presence of dissolved oxygen[12] can be ascribed to the formation of peroxides by hydrogen atoms and *A*H radicals. It should be noted that *A*H radicals have been postulated as intermediates in some enzyme reactions[11,13], and the reactions we have described may be of interest in this connexion[5].

In aerated solutions organic additions often exert a protective effect[4]. It is significant that in the present type of system organic additions can serve as potentiating agents; the effects of the radiation thus manifest themselves in good yield on components

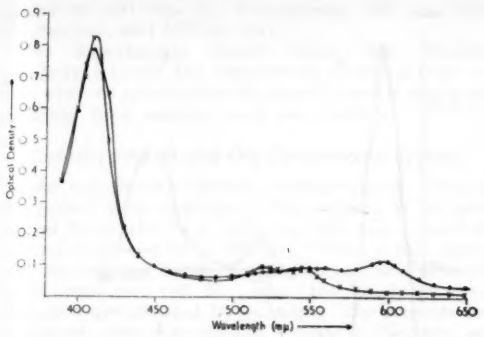

Fig. 2. Irradiation of cytochrome *c* in presence of ethanol. ●—●, absorption curve of irradiated solution after ferricyanide oxidation of reduced cytochrome *c*. ×—×, control cytochrome *c*

present in very low concentration. Moreover, in the case of coenzyme 1 and under certain conditions with cytochrome *c*, the product is not identical with the enzymatic product, and essential components of enzyme systems have thus been inactivated. It may be significant that Holmes[14] has found that in some irradiated biological systems the coenzyme 1 appeared to be the factor inactivated.

We wish to thank Dr. M. Dixon, Dr. E. Margoliash and Mr. R. P. Scutt for gifts of materials and valuable advice, and Prof. J. S. Mitchell for his interest. One of us (G. S.) is indebted to the Humanitarian Trust and the Friends of the Hebrew University for a grant. [Jan. 14.

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A NEW CYTOCHROME IN LIVING ROOTS

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THE absorption spectrum of bundles of living roots of wheat and other cereals reveals the existence of a complete cytochrome system[1], composed of prosthetic groups similar to the cytochromes *a*, *c* and *b* of animal tissues and many micro-organisms[2]. The system is responsible for 50–75 per cent of the total aerobic respiration, and it oxidizes succinate. The system has been studied in detail by means of a very sensitive new spectrophotometric technique. Already the preliminary experiments with increasing levels of reduction have indicated the appearance of a new band at 570–575 mμ after prolonged anaerobiosis. It was tentatively concluded that this band belongs to an enzyme of lower oxidation-reduction potential state than cytochrome *b* and is possibly identical with succinic dehydrogenase. On continued investigation of the absorption spectrum, it has now been found that what was hitherto believed to be a joint γ-band of cytochromes *c* and *b* is in fact due to three cytochromes, and that one fraction of the joint band with its peak between *c*. 420 and 430 mμ belongs to a substance also characterized by the α-band at 571 mμ. The substance thus behaves as a true cytochrome and may be provisionally named cytochrome *dh*.

Time-course of Reduction of Cytochromes *b* and *dh*

Even if the joint γ-band of cytochromes *b* and *dh* occasionally shows a twin peak, no significant conclusions as to the existence of a new cytochrome can be drawn from the shape of the band only (cf. ref. 3,

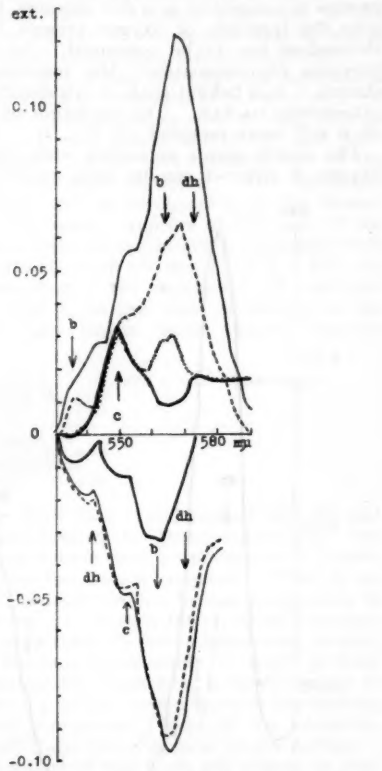


Fig. 1. Difference spectrum between roots under anaerobiosis and in aerated salt solution. The upper curves show the increasing reduction of the cytochrome system after stopping the flow of the solution. ——— after 3 min. (cytochrome *c* already completely reduced); ..... after 7 min. (joint band of *b* and *dh* with its peak near 563 mμ); – – – – after 12 min. (the peak of the joint band more toward 571 mμ); ——— after 45 min. (complete reduction; cytochrome *c* recognized as a hump at 550 mμ, joint band of *b* and *dh* with the latter dominating; β-band of *b* visible)

The lower curves show the increasing reoxidation after switching on the flow of aerated solution. ——— after 1 min. (negative bands of *c* and *b*); – – – – after 2½ min. and ——— after 5 min. (oxidation complete, joint band of *b* and *dh* moved to the right)

p. 103). Conditions must be chosen under which the steady states of cytochrome *b* and of the new cytochrome behave differently. Two ways have been tested, namely, the time-course of increasing reduction or reoxidation, and the use of specific inhibitors.

By means of the new recording technique, it can be shown that in the course of increasing reduction, beginning from the predominant oxidation in an aerated dilute salt solution, the peak of the joint γ-band moves from *c.* 431 mμ to *c.* 427 mμ, whereas the α-bands to the right of cytochrome *c* begin with a peak at 563 mμ and then extend towards *c.* 571 mμ (Fig. 1).

From a large number of such series of spectrograms the following figures were computed:

Cytochrome *b*	431 and 563 mμ (red)
Cytochrome *dh*	424 and 571 mμ (red)

The shifting of the steady states of the single cytochromes can be conveniently recorded by starting from an aerated solution and simply stopping the flow through the recipient with the roots. A more rapid reduction is attained from starting in an oxygen-free solution of succinate. In this case the process is completed in a few minutes, because now only the quantity of oxygen present in the roots themselves has to be consumed. As shown in a previous communication[4], the reduction of cytochrome *b* lags behind that of cytochrome *c* and the cytochrome oxidase. The reduction of cytochrome *dh* is still more retarded (cf. Fig. 1).

The steady states appearing when the supply of oxygen is reduced can be more closely studied if the medium is exchanged for flowing solutions having a low constant oxygen pressure. Measurable reduction starts only if the oxygen pressure sinks below *c.* 10 per cent of the normal equilibrium between solution and air. The situation at a pressure of 5 per cent of the normal oxygen tension is illustrated by Fig. 2. These roots were exceptionally rich in cytochrome *dh*, the bands of which now can be clearly observed in addition to those of cytochrome *b*.

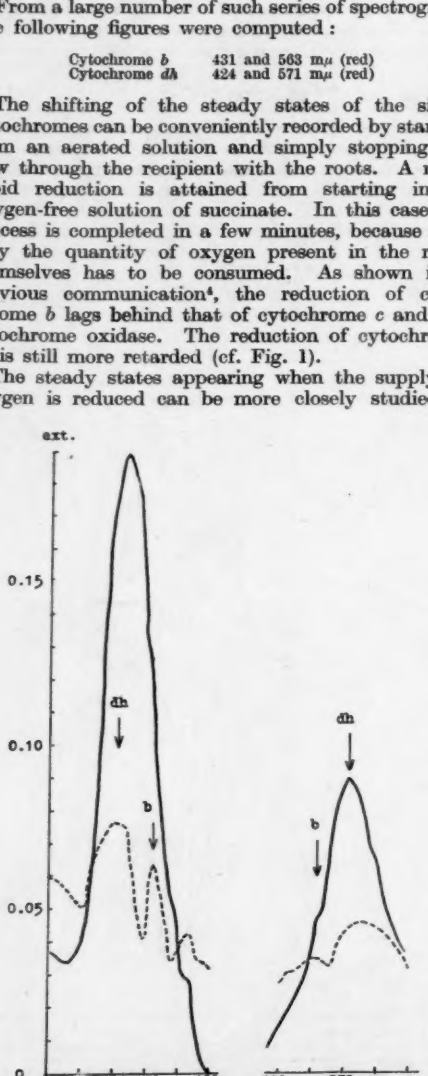


Fig. 2. ——— Difference spectrum of roots under complete anaerobiosis; cytochrome *dh* dominating. – – – – Difference spectrum of the same roots in a dilute salt solution containing 15·7 μmol. lit.$^{-1}$ oxygen (= *c.* 5 per cent of the normal tension). Separate bands of the cytochromes *b* and *dh* visible also in the γ-region (the extension of the *dh*-band to the left is caused by the *c* γ-band)

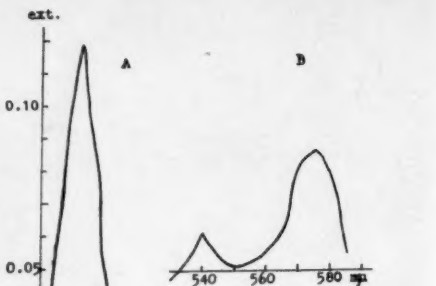


Fig. 3. Difference spectra of roots under complete anaerobiosis (———) and after treatment with 10 per cent urethane (see text). (*A*) The γ-band of cytochrome *b* in urethane (– – –) is moved to the right of the combined *b* and *dh* band under anaerobiosis (———). (*C*) The α-band of cytochrome *b* appears in urethane (– – –) to the left of the combined *b* and *dh* band under anaerobiosis (———). (*B*) Difference spectrum between the two curves in *C*, showing the reduced bands of cytochrome *dh*

Differentiating Effect of Urethane and Fluoride

Urethane uncouples the electron transfer between cytochromes *b* and *c*, leaving the former in a reduced state, if the roots are treated with oxygen-free 10 per cent urethane and then transferred to aerated urethane (see ref. 3). Because the oxidation-reduction potential of cytochrome *b* is higher than that of cytochrome *dh*, the predominantly reduced *b* is balanced by a predominantly oxidized *dh*. As a consequence of that, the peak of the γ-band is moved from *c.* 424 mμ to *c.* 431 mμ and the corresponding peak[3] at 571 mμ disappears. The spectrum of cytochrome *dh* can accordingly be calculated from the curves as the difference between anaerobiosis and treatment with urethane (Fig. 3). Besides the peaks at 424 and 571 mμ respectively, the reduced cytochrome *dh* shows a β-band at *c.* 540 mμ (Fig. 3).

The differentiating effect of fluoride is less distinct than that of urethane. 0·025–0·05 *M* sodium fluoride at *p*H 3·3–4·0 (cf. ref. 3) oxidizes cytochrome *b* almost completely and cytochrome *dh* to a considerable extent. Its effect is thus the reverse of that of urethane, because fluoride completely inhibits the reduction of cytochrome *b*, that is, the electron transfer from *dh*, and partly also inhibits the activity of *dh* itself. The net result is a shift of the joint reduced γ-bands to the left and of the α-group to the right. In the difference spectrum between roots in aerated water and roots in aerated solution of sodium fluoride, the reduced peaks consequently

appear at 431 mμ (*b*γ dominating), 535 mμ (*b*β), 550 mμ (*c*α), and 563 mμ (*b*α).

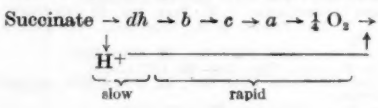
The experiments clearly show that fluoride primarily inhibits the transfer of electrons from *dh* to *b*, whereas cytochrome *dh* can still accept electrons, probably from succinic acid (see below).

Cytochrome *dh* and the Cytochrome System

Like cytochrome oxidase, cytochrome *dh* forms a compound with cyanide. The γ-band is in part moved from 424 to *c*. 435 mμ and the α-band at 571 mμ is moved to *c*. 585 mμ. This is the reason why the reduced bands of cytochrome *c* are 'cleaned' by cyanide (see ref. 3). Also, the bands of cytochrome *b* are affected by cyanide. The α-bands are weakened; but it is yet not decided if they also are displaced.

The sensitivity of cytochrome *dh* to cyanide is direct evidence against its linkage to the non-cyanide sensitive 'ground respiration'. This conclusion is supported by the observation that the bands are identically affected by cyanide aerobically or anaerobically. The obvious linkage to the succinoxidase system is, on the other hand, illustrated by the fact that reduced cytochrome *dh* is partially oxidized by fumarate (0·1 *M* at *p*H 3·3–4·0; see ref. 3) if the roots are held anaerobically, even in the presence of hydrogen cyanide. All the observed facts point in the direction of cytochrome *dh* probably being identical with succinic dehydrogenase.

In the approximate equilibrium between cytochromes *b* and *dh* attained in urethane (see above), *b* remains reduced to *c*. 90 per cent; but *dh* is oxidized to about the same degree. Assuming an oxidation-reduction potential state of 0·14–0·17 V. for cytochrome *b* (see ref. 3, p. 135), this corresponds to a potential of cytochrome *dh* slightly above zero (0·02–0·05 V.). In the steady states of the normally working cytochrome system, cytochrome *dh* will accordingly be highly oxidized and thus exert a maximum oxidizing effect on succinate. The extremely rapid reoxidation through the whole 'electron ladder' from *dh* to oxygen[4] supports the conclusion that there is a very low resistance to electron transfer from *dh* to oxygen, the actual turnover at normal respiration being regulated by the slow oxidation of succinate. This process includes the formation of protons and electrons from the hydrogen atoms detached from the succinate. The complete cytochrome system of the roots thus may be pictured in the following way (arrow = electron transfer):



Relative Concentrations of the Hæmin Enzymes in Roots and their Relation to the Quantities of Protohæmochrome

Assuming extinction coefficients of similar magnitude to those of cytochrome *c* (cf. ref. 3), the approximately equal height of the reduced bands of cytochromes *dh* and *b* points to an approximately equimolar concentration of these two enzymes in the wheat roots. The relation varies somewhat, however, and frequently shows a predominance of *dh* (cf. Fig. 2). The relation between cytochrome *b* and cytochrome *c* remains about the same as was earlier calculated, namely, *c*. 1·75. The fact that the revised values of cytochrome *b* are not very far from the earlier calculated values depends upon the shape of the absorption bands in the γ-region. Two similar bands lying at a distance of 8 mμ join to form a single band. Its peak at *c*. 427 mμ is only about 20 per cent higher than that of the single bands at 424 and 431 mμ respectively.

Wheat roots also contain peroxidase (cf. ref. 5), the concentration of which can be measured from the height of the bands at 404 and 612 mμ of the fluoride compound (cf. ref. 6). The molar concentration varies but often exceeds that of cytochromes *c* and *b*, *dh*. The band of the cyanide compound at 538 mμ [6] does not, however, appreciably disturb the appearance of the cytochrome *c* α-band at 550 mμ. Peroxidase is supposed to be reduced in dithionite only. If, however, the intracellular potential of roots during anaerobiosis promotes a reduction of peroxidase, it can be expected that the reduced band at 556 mμ will disturb the cytochrome *c* α-band at 550 mμ. This question is still unsettled; but reduction of peroxidase may be one of the reasons why in some roots in anaerobiosis the region 540–570 mμ is less transparent than would be expected from the presence of cytochromes only. Another possibility is the presence of a reserve of non-specific hæmin which is partly reduced under anaerobical conditions.

The quantity of total hæmochromes was determined after treatment of the roots with 10 per cent pyridine and dithionite. The appearance of a high, narrow band at 556 mμ and bands at 526–527 and 425–430 mμ indicates that the overwhelming part of the hæmins are protohæmochromes. On fractional extraction with 10^{-3} *M* sulphuric acid, the hæmochrome of cytochrome *c* appears at 550 mμ. If the concentration of protohæmochrome is calculated from the molar extinction at 556 mμ ($= 3{\cdot}2 \times 10^4$) the value exceeds that of the enzymes *b*, *dh* and peroxidase by only *c*. 15 per cent, as shown by the following average figures from twenty separate experiments:

Cytochrome *b*	1·43	μmol.	1	kgm.$^{-1}$	fresh weight
Cytochrome *dh*	1·49	,,	,,	,,	,,
Peroxidase	1·16	,,	,,	,,	,,
Total enzyme hæmochrome	4·08	,,	,,	,,	,,
Protohæmochrome determ.	4·80	,,	,,	,,	,,

The results show that cytochromes *b* and *dh* and peroxidase are related to protohæmochrome, but that some protohæmin may be present as a reserve or precursor of the hæmin enzymes. There is no indication of hæmoglobin-like hæmin compounds in the roots (cf. ref. 7). Even if the non-specific hæmin reserves are comparatively low in vigorously growing roots, they increase considerably in roots growing under less favourable conditions, a fact pointing to the existence of a pool of hæmin more or less shifting over into active enzymes. Most of the non-cytochrome hæmin is, however, present as peroxidase.

A detailed report of this work will appear in *Ark. Kemi* (*Roy. Swed. Acad. Sci.*). [Dec. 27.

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RADIATION-WIDTHS OF NUCLEAR ENERGY-LEVELS

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THE radiation-widths of levels of low excitation can, if sufficiently narrow ($\sim 10^{-6}$ eV.), be determined directly from the life-time of the state. The vast majority of levels, however, have much greater widths, which are often obtainable from properties of the nuclear reactions in which the levels are excited. The highly excited virtual states lying just above the energy corresponding to the neutron-binding energy have radiation-widths, for A greater than 100, of the order of 0·1 eV. These widths, typically constituting practically the total width of the level, can be measured by observation of the actual shapes of the neutron cross-section resonances that give rise to the excitation-levels. The cross-section resonances usually exhibit the simple one-level Breit–Wigner form, and the full width at half-maximum of the resonance represents the total width, Γ. The detailed shape of the resonance, in particular its peak height, allows the determination of Γ_γ, the radiation-width, by subtraction of the neutron-width, Γ_n, from Γ. The resolution available at the present time with slow-neutron velocity-selectors is sufficient to enable measurement of radiation-widths for many levels of heavy nuclei for excitation energies in the range 6–9 MeV. A survey of the radiation-widths already obtained from slow-neutron resonances reveals some interesting regularities and should be of value in its applications to theories of nuclear structure and in suggesting further measurements.

In Table 1 we present those radiation-widths that have been measured with 'reasonable' accuracy, of the order of 20 per cent. These values are based primarily on the work done in the past few years with pulsed neutron sources (the Columbia cyclotron[1] and the Harwell linear electron accelerator[2]), the crystal spectrometer at Brookhaven[3], and the 'fast choppers' at Argonne[4] and Brookhaven[5]. The present resolutions of the Harwell accelerator and the Argonne and Brookhaven choppers are about 0·1 μsec. metre, or 0·09 eV. at a neutron energy of 10 eV. and 2·8 eV. at 100 eV. A resolution of this magnitude allows determination of Γ and $g\Gamma_n$ (with g the statistical weight factor) from the resonance shape up to energies of about 10 eV., and by 'area' methods to about 30 eV. The radiation-width is obtained[6] from Γ and $g\Gamma_n$ in the general case by an assumption of $g = \frac{1}{2}$; for a zero-spin target nucleus g is known to be unity.

The first noteworthy fact concerning the radiation-widths is the small variation among levels in a single isotope and from isotope to isotope. This constancy is also shown in Fig. 1, which reveals a slight decrease of the radiation-width with increasing A. The excitation energies of the levels the widths of which are given in Fig. 1 range from 6 to 9 MeV., and represent levels in compound nuclei of odd Z–odd N (N, number of neutrons), odd Z–even N, even Z–odd N, and even Z–even N. None of these variables, however, results in differences in radiation-width larger than the spread represented by the points of Fig. 1, which deviate on the average by only 20 per cent from the solid line. It is known from neutron resonance work not reported here that the spacings of the levels for the isotopes considered vary greatly, yet this difference in spacing apparently is not reflected in a change in radiation-width. An extreme example is furnished[6] by hafnium-177 with a level-spacing of 8 eV. and hafnium-178 with 100 eV., both having similar radiation-widths.

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Table 1. Radiation-Widths of Slow Neutron Resonances

Target isotope	Spin (I)	Resonance energy (eV.)	Γ_γ(mV.)	Ref.
$^{103}_{45}$Rh	1/2	1·26	155 ± 5	*a*
$^{109}_{47}$Ag	1/2	5·21	159 ± 10	*b, c, d*
$^{113}_{48}$Cd	1/2	0·18	112 ± 5	*e, f*
$^{115}_{49}$In	9/2	14·7	80 ± 40	*g*
$^{116}_{49}$In	9/2	1·46	100 ± 20	*h, i*
		3·86	130 ± 30	*g*
		9·1	70 ± 30	*g*
		12·0	110 ± 40	*g*
$^{123}_{52}$Te	1/2	2·33	104 ± 9	
$^{133}_{55}$Cs	7/2	5·90	115 ± 20	*k*
		22·6	110 ± 40	*g*
		48	120 ± 60	*g*
$^{149}_{62}$Sm	7/2	0·096	65 ± 2	*l, m, n, o*
$^{151}_{63}$Eu	5/2	0·33	86 ± 2	*p*
		0·46	95 ± 2	*p*
		1·06	105 ± 10	*p*
$^{157}_{64}$Gd	7/2	0·03	100 ± 30	*l, m, q*
$^{}_{64}$Gd		2·58	70 ± 10	*r*
$^{176}_{71}$Lu	> 7	0·14	63 ± 5	*s*
$^{177}_{72}$Hf	< 3/2	1·08	43 ± 10	*t*
		2·36	78 ± 10	*u*
		6·3	46 ± 15	*u*
		13·9	100 ± 30	*u*
$^{179}_{72}$Hf	0	7·8	30 ± 20	*u*
$^{181}_{73}$Ta	7/2	4·29	100 ± 30	*v*
$^{183}_{74}$W	0	4·15	70 ± 20	*b*
$^{185}_{75}$Re	5/2	2·18	90 ± 20	*w*
$^{197}_{79}$Au	3/2	4·91	150 ± 20	*d, k*
		61	180 ± 60	*d*
$^{230}_{90}$Th	0	22·1, 23·8	35 ± 13*	*d*
		71	40 ± 40	*d*
$^{238}_{92}$U	0	6·7	23 ± 2	*x*

* Γ_γ assumed to be the same for these two resonances

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b Selove, W., *Phys. Rev.*, **84**, 869 (1951).
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n Sailor, V. L. (private communication). Curves are given in Sup. 1 to AECU-2040.
o McReynolds, A. W., and Andersen, E., *Phys. Rev.*, **93**, 195 (1954).
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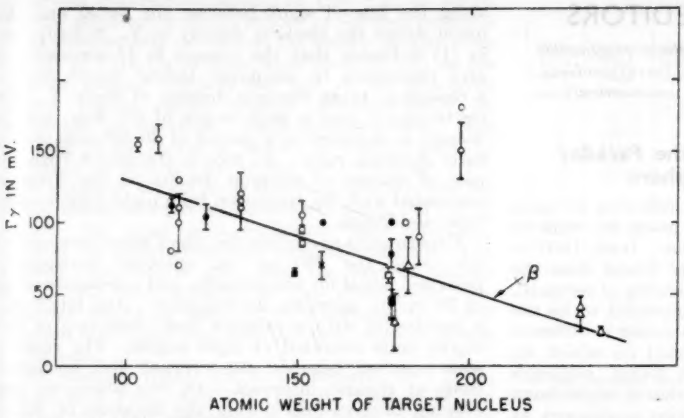

Fig. 1. Radiation-widths (Γ_γ) of slow-neutron resonance-levels plotted against atomic weight of the target nucleus. The symbols, ⊙ odd Z–odd N, ● even Z–even N, ▲ even Z–odd N, ⊡ odd Z–even N, and × assignment unknown, refer to the compound nucleus. The errors are shown for the values of Γ_γ that have an accuracy of 20 mV. or better. Almost all the other points have large enough errors to agree with the straight line β

As the levels studied represent a wide range of angular momenta, J, it is possible to investigate the dependence of Γ_γ on J, the spin of the compound nucleus. In Fig. 2, the measured widths are plotted against the spin of the target nucleus I, with $J = I \pm \frac{1}{2}$. In order to compare nuclei over a large range of A, the measured widths are multiplied by $100/\beta$, where β is the solid line of Fig. 1, in order to remove the slight dependence on A. It is obvious from Fig. 2 that there is little or no dependence of the radiation-width on J, the experimental points, with the exception of the anomalously high value for gold, being consistent with the horizontal line at 100 meV. This finding indicates that the transition probability of an energy-level (almost certainly electric dipole) is independent of J and that no $(2J + 1)$ factor should be included when comparing measured widths with theoretical transition probabilities.

The near-constancy of Γ_γ is of great value in the analysis[5] of neutron resonances in the region of poor resolution, for example, 20–200 eV. Here the variation of Γ_n from level to level is much greater than that of Γ_γ; hence, in studying the former in the 20–200 eV. region it is safe to use values of Γ_γ obtained at lower energy to obtain Γ_n from the measurements at poor resolution. The present results on Γ_γ also help to justify the use of a Γ_γ non-dependent on J in the work of Hughes, Garth and Levin[7], in which level-spacings were obtained from measured capture cross-sections at an effective energy of 1 MeV. In particular, their finding that level-spacings for different J's are about equal, which depends on the constancy of Γ_γ with J, seems justified.

It is a well-known fact that theoretical estimates of the electric dipole radiation-width of highly excited levels are much larger than experimental results. For example, Blatt and Weisskopf[8] calculate widths about 300-fold larger than those of Fig. 1, using the single-particle model. When the radiation-widths are combined with the results of capture γ-studies, which show what fraction of the total radiation-width Γ_γ corresponds to a given transition, it is possible to obtain the partial width for that particular transition. Thus Kinsey and Bartholomew[9] find by this method that identifiable electric dipole transitions, the relative strengths of which vary greatly, have widths ranging from 0·002 to 0·6 of the single-particle theoretical[8] value. (We here refer to the measured widths, suppressing the $(2J + 1)$ factor used by Kinsey in his comparison with theory, in line with the present observations.) Unfortunately, not many such cases are available because the measured total radiation-widths are usually for heavier nuclei than those used for capture-γ measurements. For much lighter nuclei[10] the electric dipole widths of states at high excitation are about 0·1 of the values for single particles[8].

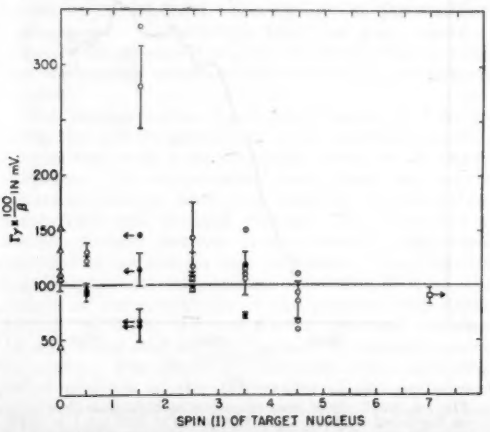

Fig. 2. Radiation-widths of slow-neutron resonance-levels plotted against spin of the target nucleus, with β the 'best' straight line of Fig. 1. The symbols are explained in Fig. 1. Errors are shown if less than 25 per cent

Thus the radiation-widths so far measured seem to have a remarkable constancy, with the sole exception of a three-fold discrepancy for gold, for different level-spacings, different J's, and different types of capture-γ decay schemes. It is possible that variations will be found in radiation-widths of isotopes not yet measured, and to this end, those exhibiting the largest differences in the characteristics just mentioned are being actively investigated.

It is a pleasure to acknowledge the help of C. E. Porter, R. C. Garth and Prof. M. H. L. Pryce in the present work, which was supported in part by the U.S. Atomic Energy Commission.

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[10] Wilkinson, D. H., *Phil. Mag.*, **44**, 450 (1953); we have again removed a $(2J + 1)$, which must be estimated for some of the examples.

LETTERS TO THE EDITORS

The Editors do not hold themselves responsible for opinions expressed by their correspondents. No notice is taken of anonymous communications

Lunar Radio Echoes and the Faraday Effect in the Ionosphere

Successful observations of the reflexion of radio waves from the moon have been made by workers in the United States and Australia. Both DeWitt and Stodola[1] and Kerr and Shain[2] found that the lunar echoes showed rapid fading (periods of seconds), for which the most likely cause appeared to be the libration of the moon. They also noted a different type of fading of much longer period for which no satisfactory explanation has been found, although Kerr and Shain obtained evidence that it might have an ionospheric origin. A radio echo equipment at the Jodrell Bank Experimental Station has recently been used in an investigation of the fading of lunar echoes; the results are in general agreement with this previous work as regards the origin of the short-period fading. The purpose of the present communication is to offer an interpretation of the long-period fading.

The equipment worked at a frequency of 120 Mc./sec. and the aerial system of 250 sq. m. aperture was arranged so that the moon could be observed for forty-five minutes at lunar transit. During thirty observing periods in the lunations of October and November 1953, 50,000 echoes were photographed and analysed. The night-time runs showed a steady r.m.s. signal amplitude (see Fig. 1*a*) while the day-time runs, particularly those within a few hours of sunrise, were characterized by severe fading (see Fig. 1*b*). The only runs which were exceptional were two night-time observations during which the fading occurred; on one of these nights there was also severe disturbance to trans-Atlantic short-wave communication, and on the other there was auroral activity. This general evidence therefore strongly suggests an ionospheric origin.

Kerr and Shain[2] showed that the movement of irregularities in the ionosphere might give rise to the fading. The speed of movement of these irregularities (300 m./sec. in the *F*-region, 50 m./sec. in the *E*-region) is, however, far too great to account for the fading periods of up to an hour observed in the present series of experiments. It is suggested that the long-period fading is due to the rotation of the plane of polarization of the radio waves as they traverse the ionosphere in the presence of the earth's magnetic field. Since the receiving aerial is plane-polarized, any slow rotation of the plane of polarization of the returned signals, as the electron content of the ionosphere varies, would give rise to changes in amplitude of the observed echoes. It can be shown from the Appleton–Hartree magneto-ionic theory that, for frequencies above 100 Mc./sec. and for restricted inclinations θ of the geomagnetic vector to the line of sight, the total polarization shift Ω for the double passage through the ionosphere is given approximately by

$$\Omega = \frac{7{,}490\, H \cos\theta}{f^2} \int N.\mathrm{d}r \text{ complete rotations}, \quad (1)$$

where f is the transmitted frequency in c./s., H the geomagnetic field in e.m.u., $N(r)$ the electron number density per c.c. and dr cm. the element of path length along the line of sight between the aerial and the moon where the electron density is N. Substitution in (1) indicates that the change in Ω necessary to give maximum to minimum fading would require a change in mean electron density of about 5×10^4 electrons/c.c. over a path length of 200 km. Such a change is observed in a period of 30–60 min. during early morning runs; its rate is consistent with the rate of change of electron density in the *F*-region associated with the transition from night-time to day-time conditions.

Experiments to confirm the effect have been carried out using the 250 sq. m. aperture horizontally polarized aerial for transmission and a separate aerial of 30 sq. m. aperture for reception; the latter was a paraboloid with a primary feed consisting of two dipole units mounted at right angles. The receiver was switched between the vertical and horizontal feeds at minute intervals. In five afternoon and evening observations during the lunation of March 1954 echoes were received in both planes of polarization, their relative r.m.s. amplitudes in the two planes varying differentially from day to day and also during the period of each run. For example, in a 45-min.

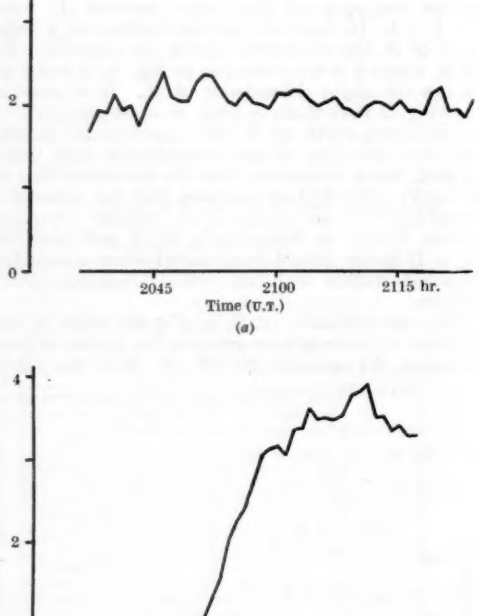

Fig. 1 *a*, Amplitude of lunar echoes during night-time observation on November 17, 1953. Lunar transit was at 2100 U.T.; *b*, amplitude record of lunar echoes during daytime observation on October 3, 1953, transit at 0846 U.T.
Ordinates are amplitude signal/noise ratios (r.m.s. of 34 echoes in one-minute periods) corrected for the moon's position in the aerial beam

observing period commencing at 1650 U.T. on March 10, the amplitudes of the echoes in the two polarizations were equally divided at the start; shortly after transit at 1713 U.T., echoes were received only in the vertical plane; towards the end of the observing period echoes again became distinguishable in horizontal polarization. Such results confirm that the long-period fading is caused, at least in part, by a change of polarization in the received lunar echo.

In equation (1) $\int N.dr$ is the total electron content of the ionosphere per sq. centimetre along the line of sight; the lunar echo technique thus affords a method for determining this quantity directly. The present experiments give only the rate of change of $\int N.dr$. Measurements at two close-spaced frequencies would be required to determine the total rotation and hence the total electron content of the ionosphere.

We wish to thank Dr. I. C. Browne, Dr. T. R. Kaiser and Prof. A. C. B. Lovell, director of the Station, for their assistance in this work. One of us (W. A. S. M.) was the recipient of a maintenance grant from the Department of Scientific and Industrial Research during 1950–53.

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Macclesfield.
April 7.

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Galactic Radio Sources of Large Angular Diameter

The survey of extra-terrestrial radiation, made at 1·89 m. with the 218-ft. paraboloid at Jodrell Bank, gave the position and intensity of 23 localized sources[1] between declinations N. 38° and N. 68°. The distribution of the intense sources showed a marked concentration close to the galactic plane, and it was concluded that they represented a class of rare objects in the Galaxy. A similar concentration has been found by Mills[2] from observations in the southern hemisphere. An attempt has now been made to measure the apparent angular width of these sources, and the present communication gives the preliminary results.

The measurements have been made at 1·89 m. using the 218-ft. paraboloid as an interferometer in conjunction with a small mobile aerial of 35 sq. m. aperture. The small aerial was placed at various distances along an east–west base-line from the fixed paraboloid, and in each position the amplitude of the interference pattern in the receiver output was recorded as the sources were in transit. The apparent angular size of each source was found from the change in the amplitude of the pattern with aerial spacing by using the well-known relation[3] between the amplitude and the distribution of intensity across the source. The effects of systematic errors and long-period changes in the calibration of the equipment were minimized by daily observation of the transit of the intense source in Cassiopeia (No. 23) for which the intensity[1] and angular diameter is already known[4,5].

Table 1

Reference No.[1]	Galactic longitude (deg.)	Galactic latitude (deg.)	Intensity* at 1·89 m. (watt. m.$^{-2}$ (c./s.)$^{-1}$ × 10^{-26})	Apparent angular width	Remarks
1	87·5	+2·1	170	—	Not measured
3	100·5	+2·1	80	>1·5°, <3°	
7	111·8	−0·3	60	>1·5°, <3°	
8	121	−1·5	50	>1·5°, <3°	
9	128·3	+3·8	80	1·4° ± 0·4°	Identified with nebulosity in Fig. 2
19	43·6	+4·9	5,700	2′ 10″ × 35″ (ref. 5)	Identified as extra-galactic (ref. 10)
20	45·9	+0·8	300	1° or 2° (ref. 9)	Cygnus X
21	56·5	+4·1	200	1·5° ± 0·4°	
22	66·4	+2·9	50	—	Not measured
23	79·6	−2·0	9,250	5′ × 4′ (refs. 4, 5, 6)	Cassiopeia I

* The intensity given is the maximum intensity observed[1] in a 2° beam. It has not been corrected for the finite size of the source.

The original survey[1] listed ten sources within ± 5° of the galactic plane, as shown in Table 1, all of which were classified as intense ($> 50 \times 10^{-26}$ watt. m.$^{-2}$ (c./s.)$^{-1}$). The present observations have been restricted to five of these sources (Nos. 3, 7, 8, 9 and 21) and the measured values of their angular sizes are shown in Table 1. The angular sizes of sources 19, 20 and 23 have been quoted from previous observations[4–6,9]. Measurements could not be carried out on Nos. 1 and 22, since serious interference was experienced in their positions from the reception of nearby intense sources in side-lobes of the aerial system.

The variation in the amplitude of the interference pattern observed at different aerial spacings for source 9 is shown in Fig. 1. The results for source 21 were almost identical. In both cases the width of the equivalent strip source is about 1½ deg. Sources 3, 7 and 8 were found to be even greater in size and it was only possible to assign an approximate lower limit of about 1½–2 deg. to their equivalent widths, since the minimum spacing between the two aerials was restricted to about 20 λ by the size of the fixed paraboloid. An upper limit to the size of these three sources of about 3 deg. has been established by inspection of the records obtained in the original survey[1].

An examination of the sky in the position of source 9 has been made by Minkowski[7] using plates

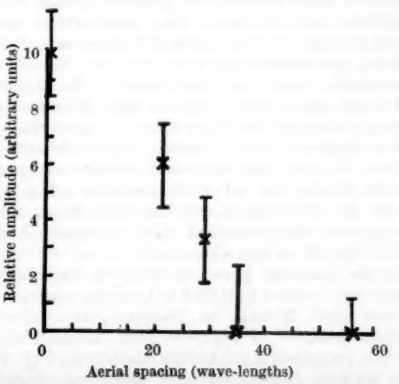

Fig. 1. The relative amplitude of the interference pattern observed from source 9. The value given for zero base-line is derived from the original survey (see ref. 1)

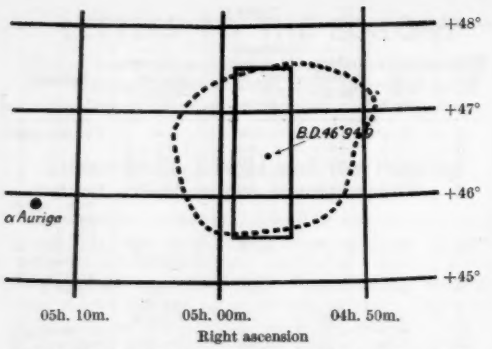

Fig. 2. A faint nebulosity in Auriga. The broken line shows the outline of the nebulosity. The position, and associated errors, of the radio source are given by the rectangle. The positions of α-Auriga and B.D. 46° 949 are shown for reference

taken during the National Geographic Survey with the 48-in. Schmidt telescope of the Mount Wilson and Palomar Observatories. He has found that in the approximate position of the source there is a faint nebulosity the outline of which is sketched in Fig. 2. The sketch has been made from an exposure taken in red light; only faint traces of the object can be seen in the blue. The nebulosity contains some faint filaments which are most prominent at the western edge. The co-ordinates of the radio source agree closely with the centre of the nebulosity, and the width of the equivalent source ($1 \cdot 4 \pm 0 \cdot 4$ deg.) is comparable with the extension of the nebulosity in an east–west direction (~ 2 deg.). In view of this agreement, source 9 may be provisionally identified with the nebulosity.

In addition to the sources listed in Table 1 three other intense sources with large angular diameters have been reported close to the galactic plane in regions outside the field of view of the present equipment. Thus Mills[2] has observed two intense sources with angular diameters greater than half a degree at $l = 229°$, $b = 0°$ and $l = 330°$, $b = 4°$. Bolton[11] has reported that the former of these two sources, in Puppis, has an angular diameter of about 1°. More recently, Baldwin and Dewhirst[8] have observed a source in Gemini with an angular width of about one degree associated with the nebulosity I.C.443. Bolton[11] has also reported the presence of extended patches of radiation in the galactic plane, nearer to the galactic centre, which may result from the presence of several of these extended sources.

Thus, by combining the data in Table 1 with observations made in other parts of the sky, a total of at least nine intense sources with diameters of the order of a degree have been found close to the galactic plane; furthermore, at wave-lengths of about two or three metres, the apparent surface temperatures of these sources are all of the order of a few hundred degrees K. The similarity between these sources is striking and suggests that they represent a definite class of object in the Galaxy.

At the present time, only five objects in the Galaxy have been identified with radio sources. These are the Crab Nebula in Taurus[12], the nebulosities in Cassiopeia[10,13], Puppis[2,11] and Gemini[8] (I.C.443) and the nebulosity in Auriga shown in Fig. 2. The radio sources associated with the Crab Nebula and with the nebulosity in Cassiopeia (source 23) appear superficially to be different in character from each other and from the remaining three. They have angular diameters of a few minutes of arc and their apparent surface temperatures are of the order of thousands and millions of degrees respectively. The remaining three radio sources, which have been included among the nine sources already discussed, appear to be similar. Their associated nebulosities all show the presence of filaments but do not resemble each other exactly; nevertheless, the association of these three sources with nebulosities, together with their similarity to the other six unidentified sources of large diameter, indicate that the origin of this class of intense radio source is to be found in extended nebulosities of low photographic brightness.

We wish to thank Prof. A. C. B. Lovell and Prof. Z. Kopal for their interest in the investigation. We also wish to thank Dr. R. Minkowski for his generous co-operation. One of us (A. R. T.) is indebted to the Department of Scientific and Industrial Research for a maintenance grant.

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Proton Polarization at ~ 130 MeV.

Recent theoretical investigations[1] of high-energy nucleon–nucleon scattering have involved the use of non-central forces in the description of the interactions between nucleons and consequently have predicted neutron and proton polarization. Experimental evidence for proton polarization was first obtained by Oxley *et al.*[2] at 240 MeV., and preliminary results from Harwell at 133 MeV., Chicago at 337 MeV. and Berkeley at 300 MeV. were reported at the Rochester nuclear physics conference[3]. Neutron polarization effects are much smaller than proton polarization effects under all the experimental conditions investigated to date[3].

Nucleon polarization is detected in a double-scattering experiment. If the angle between the normals to the two scattering planes is φ and the angles of the first and second scatterings are θ_1 and θ_2, then it may be shown that the asymmetry, ε, in the beam intensities $I(\varphi)$ after the second scattering is

$$\varepsilon = \frac{I(0°) - I(180°)}{I(0°) + I(180°)} = P_1(\theta_1)\, P_2(\theta_2),$$

where $P(\theta)$ is the fractional polarization produced by a single scattering.

In the present experiment the internal (presumably unpolarized) proton beam of the Harwell cyclotron was scattered through 20° by a 10-MeV. thick copper or carbon target and was extracted from the machine by the aid of a magnetic deflector channel in an arrangement suggested by J. M. Cassels. The proton energy selected by this channel was 133 MeV., while the effective primary beam, taking into account multiple traversal effects, covered a range of 143–166 MeV. The polarized proton beam from the carbon first target had a flux of 3×10^8 protons/sec./cm.^{2} at the second target, which was located behind a 6-ft. thick shielding wall and at a distance of 25 ft. from the first target. The beam from the copper target was 10^5 protons/sec./cm.^{2}. The protons scattered from the second target were counted in a triple-coincidence scintillation counter telescope with an azimuthal acceptance angle of 8°. When polyethylene was used as a hydrogen second target, the recoil protons were counted in coincidence with the scattered protons. The telescope could be moved in the plane of the scattering to vary θ_2, and the framework on which it was mounted could be rotated about the axis of the beam to vary φ.

We shall use the notation (X, Y, θ_2) to denote that the first and second targets were of materials X and Y respectively and that the angle of the second scattering was θ_2.

For conditions (C, C, 20°), (C, C, 30°) and (C, U, 20°), the asymmetry, ε, increased as the threshold energy, E_T, for proton detection by the counter telescope was raised (Fig. 1), while for (C, H, 20°) ε was, of course, independent of E_T and was equal to $0{\cdot}14 \pm 0{\cdot}02$. For (C, C, 45°) and (C, U, 45°) ε was small (not statistically different from zero) for $E_T = 45$ and 112 MeV. The largest values of ε were found to be associated with a high-energy group of elastically or near-elastically scattered protons. In Fig. 2 are drawn the proton-energy spectra deduced from the

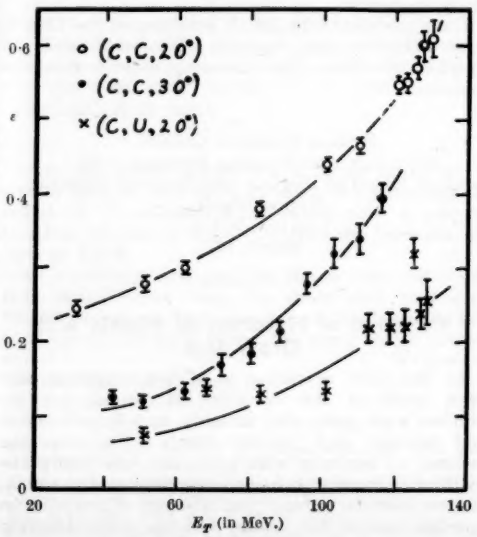

Fig. 1

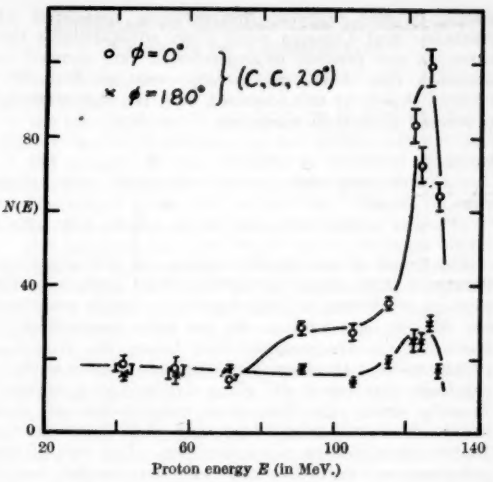

Fig. 2

absorption curves of (C, C, 20°), showing a very strong peak at the full energy corresponding to elastic scattering of the protons; the 'elastic' peak was much smaller for (C, C, 30°) (consistent with the first diffraction minimum near 30°), but it was well defined for (C, U, 20°). The asymmetry of 0·6 for (C, C, 20°) implies that P_1 and P_2 ('elastic') are both greater than 0·6. Now, making the assumption that there is no appreciable variation with energy between 133 MeV. and 143–166 MeV., P_1 must be less than P_2, since the first scattering was not all elastic scattering; consequently, $0{\cdot}6 < P_1 < 0{\cdot}8$ and $0{\cdot}8 < P_2$ ('elastic') $< 1{\cdot}0$. The asymmetry for inelastic scattering was much smaller than for elastic scattering. A diffuse group of protons was apparent for (C, C, 20°) with energies approximating to the free p–p scattering energy, and for this group $\varepsilon = (0{\cdot}27 \pm 0{\cdot}05)$. No groups could be distinguished for (C, C, 30°) or (C, U, 20°), but in the appropriate energy-ranges ε was $(0{\cdot}15 \pm 0{\cdot}05)$ and $(0{\cdot}05 \pm 0{\cdot}03)$. Below 70 MeV. the scattered protons showed no significant asymmetry.

In a similar beryllium – beryllium asymmetry measurement at Chicago at 337 MeV., ε was found to increase with E_T in such a manner that it was concluded that all the polarization effects were due to elastic scattering. At Berkeley the results of (C, C, 15°) measurements were interpreted as showing that both elastic and inelastic scattering produce asymmetry. There is therefore some uncertainty as to whether or not all the polarization is due to elastic scattering at about 300 MeV., whereas our results unambiguously show quite a pronounced asymmetry for the inelastic events.

The angular distribution (15°–45° lab.) of the (C, H, θ_2) asymmetry is shown in the table. If the beam polarization, P_1, is $(0{\cdot}7 \pm 0{\cdot}1)$ the free proton–proton polarization, P(H), is $(0{\cdot}20 \pm 0{\cdot}05)$ at 20°. The value of P(H) obtained by Oxley *et al.* at 200 MeV. was $(0{\cdot}22 \pm 0{\cdot}04)$ ($\theta_1 = 19°$, $\theta_2 = 27°$). Measurements at Berkeley of (C, H, 20°) and at Chicago of (Be, H, 20°) reported at Rochester[3] both gave $\varepsilon = 0{\cdot}2$, and from other measurements P_1 was at least 0·5, so that at 300 MeV. $0{\cdot}2 < P(\mathrm{H}) < 0{\cdot}4$. There are therefore no large differences between the p–p polarizations at 130, 200 and 300 MeV. The

shape of the angular distributions measured at Berkeley and Chicago were both substantially the same as the present measurements, but showed in addition that $P(H)$ was nearly constant from 20° to 5°. This is to be compared with the theoretically predicted $\sin\theta\cos\theta$ variation.

θ (lab.)	15°	17½°	20°	25°
ε	0·19 ± 0·03	0·19 ± 0·025	0·14 ± 0·02	0·11 ± 0·015
θ (lab.)	30°	35°	40°	45°
ε	0·11 ± 0·02	0·07 ± 0·02	0·045 ± 0·03	−0·01 ± 0·015

The most direct interpretation of our measurements is that elastic scattering from carbon yields protons at 20° and 30° which are very highly polarized (> 80 per cent and > 60 per cent, respectively); these values are roughly four times the free p–p polarization at these angles. Similarly, elastic scattering from uranium at 20° gives a polarization approximately twice the free p–p polarization at that angle. Inelastic events also may yield polarizations higher than that in p–p scattering. The sign of the polarization effects has not been determined, but it is the same for nuclear and p–p polarizations.

This work on proton polarization effects is continuing and a fuller report will be issued later. We wish to thank Dr. T. C. Griffith for his collaboration in some of these experiments, and Dr. T. G. Pickavance and Mr. B. Rose for their continued encouragement and advice.

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Errors in Particle-size Determination from Settled Suspensions

The particle-size distribution of finely divided materials is sometimes obtained by sizing settled suspensions under the microscope. This distribution is then assumed to represent that of particles orientated at random. In recent experiments on the extinction of light by silica dust suspended in liquid the cross-sectional area obtained microscopically seemed too large. Since the suspended particles were fairly uniform in size, it seemed improbable that the discrepancies arose from sizing errors, and more likely that the particles of extreme shape tended to settle flat on the slide.

In order to obtain samples which had not been orientated in this way, the particles were suspended in carefully filtered agar solution, and the suspension for sizing poured on to a microscope slide under conditions such that it set within a few seconds. In this way the orientation of the suspended particles was 'frozen in'. Hydrodynamic effects may orientate the particles in the agar before it sets, but they are unlikely to give rise to the same errors in sizing as does the orientation of the settled suspension.

The particles were then sized by microscope, using a Patterson–Cawood graticule, and classified according to their projected areas. The technique employed was that used in the sizing of settled particles, except that the microscope was racked up and down to focus through the depth of the agar film. The size distributions obtained by the two methods were compared by means of the χ^2 test. Some of the original seven or eight size-groups had to be combined owing to the small numbers of particles in the larger groups.

Table 1

Size range, microns	Mean area per particle (microns²) and number sized (in brackets)		Significance level, difference between distributions: χ^2 test
	Settled	Suspended in agar	
8–30	359 (660)	322 (278)	$P < 0{\cdot}1$ 5 *D.F.*
4–20	115·7 (663)	89·7 (452)	$P < 0{\cdot}001$ 5 *D.F.*
2·4–7·5	29·0 (409)	23·0 (248)	$P < 0{\cdot}001$ 4 *D.F.*
1·2–4	4·88 (399)	3·67 (153)	$P < 0{\cdot}02$ 6 *D.F.*

Four different suspensions were studied (see Table 1). In each case the upper size-limit quoted embraced more than 90 per cent of the particles sized; most particles lay within considerably narrower ranges. There seems little doubt that the distributions are different, and can give rise to considerable differences in mean area per particle. The mean areas are, however, subject to considerable statistical errors owing to the small numbers of particles sized.

It is possible that similar differences in distribution might be obtained from apparently identical preparations. Three pairs of such identical preparations were therefore compared by the same technique; but no significant differences were found. The differences between settled and 'frozen-in' suspensions appear, therefore, to be real. The cross-sectional areas obtained by the latter method gave good agreement with those indicated by the light-extinction.

For particles smaller than about 1 micron diameter, the method becomes very difficult to use. Objectives of high magnification, short focus and small depth of focus must be used, and the volume in focus at any one time is small. Moreover, Brownian movement becomes more important and orientation seems less likely to persist.

I am grateful to Mr. M. J. Robbins, of the Department of Bacteriology, London School of Hygiene and Tropical Medicine, for preparing artefact-free agar solution.

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Variation of Hardness of Metals with Grain Size

In the past, several sets of measurements have been made of the variation of Brinell hardness number with grain size, notably on α-brass[1], copper and bronze[2], and 'Armco' iron[3]. The consistent increase of hardness with grain size was interpreted by these workers[2,3] as being dependent on the amount of grain boundary area; that is, a plot of the hardness number against $1/d$, where d is the grain diameter, gave a straight line. However, I have found that a

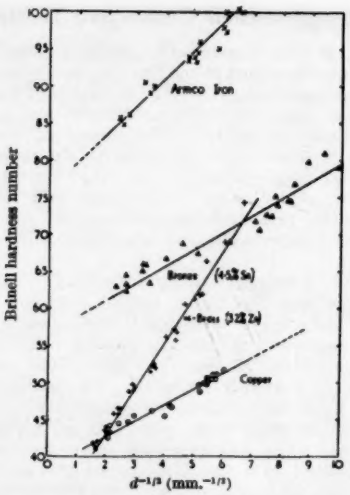

Fig. 1

plot of hardness number against $1/d^{1/2}$ gave equally 'good' straight lines, since the scatter in the original results was rather high, and in one case (α-brass) an even better fit was obtained (Fig. 1).

An interpretation of the results then appears possible, following the treatment of the variation of the lower yield stress in mild steel with grain size, which obeys a similar law[4]. When an indentation is made in a metal surface, the size of the indentation can only increase by plastic yielding in the surrounding grains. The transmission of deformation from one grain to another can be pictured on the following model: assume dislocations to pile up against a grain boundary, then the stress σ at a distance x ahead of the dislocation nearest to the grain boundary is given by

$$\frac{\sigma}{\sigma_0} \simeq \left(\frac{L}{x}\right)^{1/2},$$

where σ_0 is the applied stress, and L is the length of the glide plane[5]. The adjacent grain will yield when σ reaches a certain critical value, and, identifying L with the mean grain diameter d, we find

$$\sigma_0 \propto \frac{1}{d^{1/2}}.$$

Thus all grains supporting a stress equal to or greater than σ_0 will have yielded, and assuming the extent of the plastically deformed zone is proportional to the size of the impression, the hardness will vary as $1/d^{1/2}$.

Alternatively, this analysis shows that the (local) yield stress varies with the grain size, and since Tabor[6] has shown that the Brinell hardness is proportional to the yield stress, the same result follows.

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Inhibition of Glucose Use in Muscle Extracts by Lipoproteins

Following the demonstration that the serum of severely diabetic rats inhibited the uptake of glucose by the rat diaphragm[1] and the later finding that such inhibition was dependent on the lipoprotein content of the serum[2], it was decided to test the effect of lipoprotein fractions obtained from diabetic plasma, the anterior pituitary and other tissues on the utilization of glucose by cell-free muscle extracts.

The lipoproteins used have been obtained either by alcohol fractionation of plasma[2] or by flotation in the ultracentrifuge at an appropriate specific gravity, the lipoprotein being removed and precipitated with zinc for purposes of storage. In the earlier experiments the lipoproteins were dissolved and then dialysed against several changes of saline; but as the possibility had to be considered that zinc ions may be inhibiting some enzymes in the system[4], in the more recent series reported here (Table 1) versene (ethylenediaminetetraacetic acid) has been used to bind the cation, or else zinc has been removed by passage through an appropriate ion-exchange resin prior to dialysis. All extracts were tested for zinc content with dimethylthiocarbazone, and under the experimental conditions used the maximum concentration of zinc in the system was less than 1×10^{-7} *M*.

The effect of such fractions has been tested on a standard system consisting of: glucose, 1·2 micromoles; muscle extract, 0·2 ml. (1 gm. muscle extracted with 1 ml. saline and adjusted to *p*H 7·45); phosphate buffer (*p*H 7·45), 10 micromoles; adenosine triphosphate, 5 micromoles; Mg^{++}, 5 micromoles, the appropriate amount of lipoprotein solution and water to a total volume of 0·7 ml. The system was incubated for 15 min. at 37° C. and glucose determined after deproteinization.

The glucose utilized has been calculated by difference between experimental results and incubated systems containing no adenosine triphosphate. The results obtained are shown in Tables 1 and 2. As the fraction obtained by alcohol fractionation of plasma is contaminated by other proteins, the quantity used is expressed as ml. of original plasma.

In addition to the experiments shown in the tables a large number of other experiments have been made with minor variations in technique. In all cases inhibition of the system by lipoprotein has been demonstrable, although with plasma lipoproteins the amount required to produce inhibition varies considerably from sample to sample. One of the most marked features has been the minute quantity of anterior pituitary lipoprotein which has produced well-marked inhibition, as little as 3 μgm.

Table 1. Inhibition of Glucose Use by Lipoprotein* from Plasma of Diabetic Rats

Exp. No.	Quantity LP added (as equiv. original plasma in ml.)	Glucose utilization in μgm.		
		Control	With LP	With LP + I†
1	0·4	117	90	100
2	0·4	181	140	144
3	0·2	104	76	100
4*a*	0·4	135	38	35
4*b*	0·4	138	38	55
5	0·6	110	90	90
6	0·4	143	98	97
7*a*	0·08	156	148	160
7*b*	0·2	156	139	135
7*c*	0·4	156	120	118
8	0·4	78	36	84
9	0·4	125	80	102

* Lipoprotein freed of zinc prior to use. † Insulin, 0·1 unit per ml.

Table 2. Inhibition of Glucose Use by Tissue Lipoprotein

Exp. No.	Source of lipoprotein	Quantity LP added as μgm. protein	Glucose utilization in μgm.		
			Control	With LP	With LP + I
1	Ant. pituitary, ox	3	137	131	128
		8	137	119	119
		16	139	74	84
		32	139	59	54
2	Ant. pituitary, ox	3	100	91	97
		8	100	77	88
		16	100	70	68
		32	100	47	54
3	Ant. pituitary, ox	3	126	97	105
		8	126	75	81
4	Liver, rat	16	118	82	78
		32	118	54	53
5	Muscle, rat	16	118	92	94
		32	118	68	72

being effective on a number of occasions. However, pending the demonstration of hormonal activity in such preparations, it would be premature to draw conclusions as to the physiological role of lipoprotein fractions in the control of carbohydrate metabolism.

In view of the proposal that insulin may influence glucose utilization directly[5], the effect of insulin upon the lipoprotein inhibition was explored; the insulin, where present, was 0·1 unit per ml. Most irregular results were obtained, as recorded in Tables 1 and 2. The irregularity is best shown in Table 1, where in Exp. 4 the same materials were used at 4-hr. intervals and the second test showed an apparent insulin effect but the first did not; again, in Exp. 7, with three tests done simultaneously, an insulin effect was obtained in one, but not in the other two. Altogether, in forty-two experiments done recently, a reversal of the inhibition by insulin was observed in twelve. Other proteins were tested in place of insulin, namely, insulin inactivated by alkali, glucagon, hyaluronidase, and serum albumin; in no instance was reversal of lipoprotein inhibition observed. However, in view of the irregularity of insulin effects, it is not possible to state whether this is of significance in a small series. For the same reason, no conclusions can be drawn at present as to whether such a mechanism is concerned with the physiological action of insulin.

In summary, lipoproteins from plasma, anterior pituitary, liver, and muscle have been found to inhibit glucose utilization by muscle extracts. Insulin reversal of this inhibition has been observed in a limited number of experiments.

This work, which was initiated by the authors in the Department of Biological Chemistry, Washington University, St. Louis, is being continued, and full details will be published elsewhere.

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Fibrogenesis in Connective Tissues

While it is now generally accepted that the cell plays a dominant part in the fibrogenesis in connective tissues, the mechanism of the formation of the fibrils of collagen and those of elastic tissue and cartilage is completely unknown. The object of this communication is to direct attention to the presence of sub-microscopical filaments in the cytoplasm of fibroblasts, osteoblasts, osteocytes and chondroblasts. The present observations were made with the electron microscope and using ultra-thin sections of tissue.

Sections of normal thickness for study in the light microscope and the much thinner sections for the electron microscope were each prepared from the middle segment of the metatarsal rudiment of embryonic fowls of age 4–15 days, and from the mandible of 7–12-day embryos. All specimens were fixed in 1 per cent osmium tetroxide at *p*H 7·4 [1] and embedded in ester wax over *n*-butyl alcohol and chloroform. The specimens for electron microscopy were mounted on a standard coated grid and viewed in a Metropolitan-Vickers electron microscope Type *EM*3 at 75 kV., a 30-μ or 60-μ objective aperture being used.

The control sections show that at about the sixth day of incubation the cells which surround the cartilaginous shafts of the metatarsus differentiate into an outer fibroblastic and an inner osteoblastic layer. In electron micrographs of transverse sections of this central hypertrophic region, the cytoplasm of the osteoblasts is seen to be packed with long fine filaments about 120 A. in diameter, some of which enlarge to about 500 A. in diameter in later development (Fig. 1). The filaments often lie in pairs, and each appears to be joined to its neighbour by short junctions at intervals of about 700 A., while others seem to be twisted together into a complex helix. These single and composite filaments are usually parallel to each other and are separated by distances of 200–1000 A.; they are also associated with mitochondria and in some cells seem to be woven around the latter.

As the age of the fowl embryo increases, the innermost layer of osteoblasts becomes sharply defined from the adjacent cartilage by a narrow dense strip which indicates the first stage of ossification. Where the cytoplasm of the osteoblasts is in immediate contact with this periosteal bone, no dividing line between the developing matrix and intracytoplasmic filaments can be distinguished; it appears that the filaments become part of the bone matrix. At present the mechanism whereby the organic matrix is laid down is not understood, as round electron-dense particles which may be related to the deposition of mineral salts are scattered throughout the region, and this quickly renders the bone matrix opaque to the electron beam.

Similar, though fewer, intracytoplasmic filaments have been observed in osteocytes of the periosteal bone, in osteoblasts and osteocytes of endochondral and membrane bone, in fibroblasts of the perichondrium and of tendon sheaths, and in chondroblasts of the hypertrophic cartilage in long bones and in the ossifying articular region of Meckel's cartilage. In the last, only single, long, well-separated filaments have so far been recorded; the other types of fibrogenic cells contain mainly short filaments and particles, and only a few contain long orientated filaments. The appearance of the micrograph, even in a cell

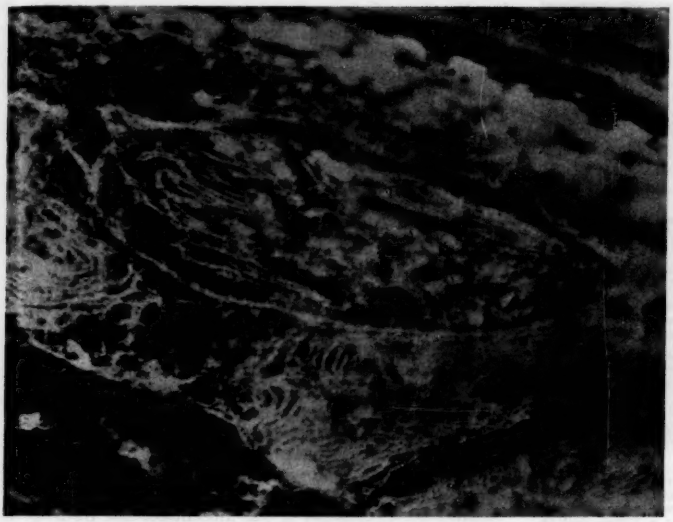

Fig. 1. Electron micrograph of a section through the osteoblastic layer of the periosteum which lies adjacent to the developing periosteal bone in the metatarsus of an 11-day fowl embryo. The cytoplasmic regions are packed with filaments, while electron-dense particles can be seen in the osseous sheath visible in the upper part of the photograph. × 14,000

with well-aligned filaments, varies according to the plane of section with respect to the orientation of the filaments, and the orientation itself varies from cell to cell.

It is striking that in transverse sections of the metatarsus, that is, in sections cut at right angles to the long axis of the bone rudiment, the osteoblasts of the periosteum display long intracytoplasmic filaments which are parallel to one another and lie precisely in the plane of the section. It is possible that this orientation has been brought about by subjection of the tissue to tension during growth, for the layer of osteoblasts may be compressed between the outer fibrous coat of the periosteum and the expanding cartilage of the shaft[2]. Longitudinal sections cut tangentially through the osteoblastic layer show similar precisely aligned filaments. But in longitudinal sections cut through the long axis of the shaft intracytoplasmic filaments are not observed in the osteoblasts; instead, the cytoplasm shows granules with no precise orientation which may well represent the filaments in cross-section. These observations indicate that the long axis of the filaments in the cytoplasm lies at right-angles to the length of the bone rudiment and that the filaments are arranged in layers within the osteoblasts of the periosteum.

The use of thin sectioning techniques during the past few years has added much to our knowledge of cytoplasmic content and submicroscopical structure[3]. The observations have been interpreted in various instances to indicate the presence of lamellæ, tubules and double membranes. Such structures appear to be associated particularly with the basophilic regions of protein secretory cells. Careful examination of hundreds of micrographs strongly indicates that the cytoplasm of all the fibrogenic cells which have so far been investigated contains filamentous bodies; the observations are not at present consistent with the presence of membranes or tubules. There is thus no obvious reason at this stage for relating the cytoplasmic structures of the cells concerned in collagen formation with the intracellular structures occurring in secretory cells of the parenchyma.

The presence of intracellular cytoplasmic filaments in fibrogenic cells does not in itself establish that such structures play a direct part in fibrogenesis. The absence of any visible demarcation between the osteoblasts and the periosteal bone (Fig. 1), and the close resemblance of the cytoplasmic filaments and the intercellular fibrils of the bone matrix, suggest that the filaments may become extracellular. Further work in progress will show whether this hypothesis is correct. An attempt is also being made to determine the chemical nature of the intracellular filaments. This also should have an important bearing on the mechanism of fibrogenesis in connective and skeletal tissues.

I am indebted to Dr. H. B. Fell, Prof. J. T. Randall and Dr. W. Jacobson for their continued advice and encouragement.

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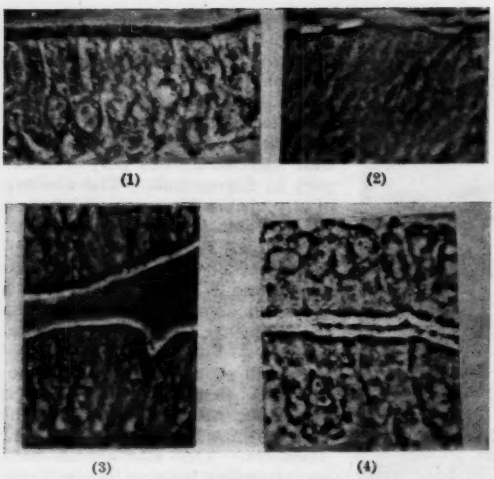
Phase-Contrast Microscopy of the Gomori Reaction for Alkaline Phosphatase

In the standard Gomori technique for the histochemical demonstration of alkaline phosphatase, calcium phosphate deposits are formed in sections supposedly at sites of enzyme activity. These deposits, thought to be invisible, must be brought to light by a further procedure. Calcium may be converted to cobalt and the latter visualized as the black sulphide; the von Kossa silver technique may be employed; or lake-forming dyes may be used for colouring the deposits.

We have carried out experiments using paraffin sections of alcohol-fixed duodenum from young rats. Following incubation in substrate[1] in the usual way, we have rinsed the slides in distilled water buffered at *p*H 9·20 with sodium barbital, dehydrated, and mounted them direct in Canada balsam without any further treatment. We have studied their appearance with the phase-contrast microscope and have observed progressive changes in the appearance and optical properties of the sections as incubation proceeds. The changes do not take place in sections incubated in a substrate bath lacking phosphate ester or in sections heated to destroy intrinsic enzyme prior to incubation.

Control sections were dewaxed, taken to buffered water for 2 min., dehydrated and mounted. Compared with these, after 1-min. incubation the brush



(1) 1-min. incubation. The epithelial free border appears dark (phase positive) and striations may be distinguished. (2) 2-min. incubation. Striation is no longer visible. Two phase-negative areas are present in the border, separated by a phase-positive zone. To the right, the border is almost invisible. (3) 4-min. incubation. The border is now continuously phase negative. In the upper portion it contains minute 'pre-crystals' while, in the lower part, larger (black) crystals are to be seen slightly out of focus. (4) 16-min. incubation. The border is filled by a shining, solid mass of crystals.

Phase-contrast photographs. × 750

border of the cells appears slightly darker and more clearly striated (Fig. 1). After 2 min. the optical properties of the border are affected in a patchy manner. In some places it remains darker than the background (that is, phase positive); in others, it becomes invisible; while elsewhere, transmitting more light than the background, it becomes markedly phase negative (Fig. 2). Minute phase-negative crystal-like structures ('pre-crystals') can just be resolved within such areas; but striation is no longer visible. After 4 min. the border is continuously phase negative and, in addition to 'pre-crystals', quite large, shining crystals appear (Fig. 3). These increase rapidly with time until after 16 min. they form an almost solid mass which fills the border completely (Fig. 4).

If the coverslip is removed from such a section and the slide is remounted in bergamot oil instead of Canada balsam, the phase-changes and 'pre-crystals' can no longer be seen. The border appears dark, without 'pre-crystals'; the crystals also are more difficult to define. If the section is once again mounted in balsam, it reverts to its original appearance. Bergamot oil has a lower index of refraction than Canada balsam. This suggests that the reversal of phase behaviour is due, not to a simple loss of substance from the section during incubation, but to alterations in the refractive index of its different parts resulting from the superimposing of some material thereon during incubation. The phase-changes, the 'pre-crystals' and crystals are all abolished by brief immersion in dilute mineral acids; moreover, gypsum crystals can be seen to form over the border when a drop of melted glycerine jelly acidified with sulphuric acid is added. These facts suggest that, as might be expected, the material deposited and responsible for the phase-changes and crystal formation is in fact calcium phosphate.

We are studying the effects of longer incubation periods, the behaviour of other tissues and freeze-dried material, with the object of comparing the localization of sites of enzyme activity indicated by this new method with the classical techniques.

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Silk–Phosphoric Acid Solutions

Natural silk is readily soluble in several solvents, such as cupriethylenediamine, lithium bromide and lithium rhodanide, phosphoric acid, etc. Generally, it is assumed that the dissolution is brought about in such a way that the solvent splits the hydrogen-bonds which intermolecularly connect adjacent fibroin chains, attaches itself to the positions now made available and thus transforms the fibroin into a hydrophilic, water-soluble modification. Schauenstein[1] stated that this procedure could be followed by means of ultra-violet spectroscopy by virtue of the 'peptenol' chromophore, the intensity of which should be a measure of the intermolecular hydrogen-bonding, and which shows a distinct and specific absorption in the region of about 250 mμ. In the course of regeneration experiments with phosphoric acid solutions, different silk samples were investigated in a Beckman spectrophotometer, namely, natural silk, silk dissolved in phosphoric acid (diluted with water), the aqueous silk solution obtained by dialysing the phosphoric acid solution and, finally, films prepared by drying the aqueous solution. The absorption curves obtained are shown in Fig. 1. In view of the above considerations, this result would mean that natural silk contains by far the largest amount of intermolecular bonds, whereas the phosphoric acid solution has lost most of them. Yet the aqueous solution shows an increase in the hydrogen-bonding, and still more so does the film, although without reaching the high value of natural silk.

Independently of this problem, the question arises whether all the solvents mentioned cause decomposition of the silk molecule or not. Howitt[2] claimed that

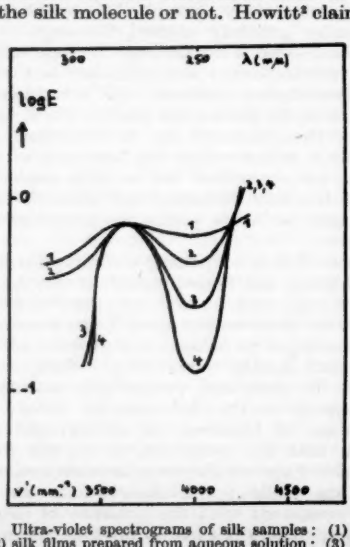

Fig. 1. Ultra-violet spectrograms of silk samples: (1) natural silk; (2) silk films prepared from aqueous solution; (3) aqueous silk solution; (4) phosphoric acid–silk solution

cupriethylenediamine does not do so; but Signer[3] has recently doubted that statement. Lithium bromide[4] and lithium thiocyanate[3] seem to maintain the original molecular weight. We have examined the phosphoric acid solutions by means of viscosity measurements extending over a period of 30 hr. It was found that a noticeable decrease of intrinsic viscosity takes place, as shown in the table.

Time	$[\eta]$
10 min.	1·13
5 hr.	0·82
25 hr.	0·54

This decrease in viscosity may be caused by either a molecular rearrangement (folding of chains) or by an actual decomposition of the silk molecule; or by both these effects. Although a decision based on these results is not possible, to us the second explanation (decomposition) seems the more probable one. It might also explain the numerous difficulties encountered when trying to spin useful fibres from phosphoric acid solutions[5].

Finally, one further observation should be mentioned. If the process of dissolving silk in phosphoric acid is observed under the microscope, it is seen that the acid first attacks the fibre at regularly spaced positions, thus after a few seconds creating the impression of a dotted line (with segments of about 100 μ in length). A few minutes later complete dissolution is achieved.

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Synthesis of Oligosaccharides during Enzymatic Hydrolysis of Cellobiose by *Aspergillus flavus*

During our investigations on the synthesis of oligosaccharides from simple sugars by various mould extracts it was found that the mycelial extract of *Aspergillus flavus* was capable of synthesizing oligosaccharides from cellobiose. The dialysed extracts of the mould converted cellobiose into glucose and four other saccharides, three of which occupy positions below cellobiose and one between cellobiose and glucose on the paper chromatogram. Similar observations were reported recently by Crook and Stone[1] by the action of *Aspergillus niger* on cellobiose. The substances were not identified. Barker *et al.*[2] have recently reported the synthesis by *Aspergillus niger* (strain 152) of some oligosaccharides which were identified as β-linked glucosaccharides. In view of the importance of this reaction in carbohydrate metabolism and in the mechanism of the synthesis of oligosaccharides, we report in this communication the results obtained on the identification of the substances formed from cellobiose.

Dialysed extract (5 c.c.) of *Aspergillus flavus* was added to a mixture containing 5 c.c. of 20 per cent cellobiose in 0·02 *M* acetate buffer (*p*H 5·0) and

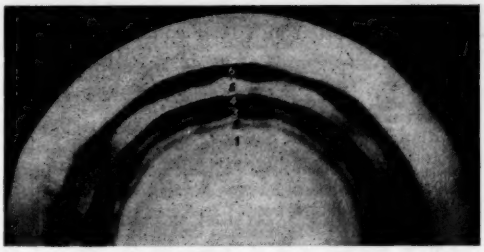

Fig. 1. Semicircular chromatogram showing the separation of glucose and oligosaccharides formed after 15 days of incubation of cellobiose with the mycelial extract of *Aspergillus flavus*. Solvent: butanol–pyridine–water (60 : 40 : 30); reagent: aniline–hydrogen phthalate; Whatman No. 3 (22 cm. diam.). Double development.
1, Oligosaccharide (1); 2, oligosaccharide (2); 3, gentiobiose; 4, cellobiose; 5, unidentified band; 6, glucose

incubated at room temperature (21–24° C.). Aliquots were removed at known intervals and the sugars and oligosaccharides formed were separated and identified by circular paper chromatographic technique[3] according to the procedure recently reported for the separation of sugars[4]. Butanol–pyridine–water (60 : 40 : 30) and butanol–acetone–water (20 : 70 : 10) were used as solvents and aniline–diphenylamine–phosphoric acid[5] and aniline–hydrogen phthalate[6] as reagents. Fig. 1 shows the chromatogram of the saccharides formed after fifteen days of incubation. The oligosaccharides were identified by running multisector chromatograms of the digest and a mixture of cellodextrins obtained by deacetylation[7] of cellulose acetolysate[8] and gentiobiose, which was kindly supplied by Dr. W. J. Whelan, of the University College of North Wales, Bangor. It was observed that during the first 16 hr. of incubation glucose and the oligosaccharide (2) were formed, followed by the formation of oligosaccharide (1) after 72 hr. On the eighth day of incubation the oligosaccharide (3) was formed and its concentration increased at later stages. A faint band (4) appeared at the initial stages which did not increase in intensity after fifteen days of incubation. Only one of the oligosaccharides (1) corresponded with a cellodextrin occupying the position below cellobiose on the chromatogram. The oligosaccharide (3) occupied the same position as that of gentiobiose and isomaltose. All the oligosaccharides showed reducing action towards the reagent triphenyl tetrazolium chloride. Complete hydrolysis of the oligosaccharides (1) and (2) after elution from the paper yielded glucose as the only product.

These observations indicate the occurrence of enzymes in the mould, which synthesize oligosaccharides from cellobiose by the same mechanism of transglucosidation as suggested by Pazur and French[9] for the synthesis of oligosaccharides by the enzymic action of fungal cultures on maltose. The enzymes of *Aspergillus flavus* convert cellobiose into glucose and oligosaccharides (1) and (2) which appear in the initial stages and also convert cellobiose into gentiobiose, a conversion similar to that of maltose into isomaltose by *Penicillium chrysogenum* —*Q*176 [10] and other moulds[9]. The gentiobiose was identified provisionally from the study of the R_F values of the substance in various solvents, the reducing action and colour reactions with aniline–diphenylamine–phosphoric acid, which was found to be a useful reagent for differentiation of sugars with 1–4 and 1–6 glycosidic linkages[3]. Further work on the isolation and characterization

of the oligosaccharides and the enzymes is in progress and will be reported in a later communication.

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Absorption of Phosphorus-32 from the Rabbit Vagina under Various Hormonal Conditions

It has been known for a long time that the vagina of different animals absorbs many substances, for example, poisons of various kinds, dyestuffs, semen, etc. (for references see Bengtsson[1]). As the condition of the vagina is influenced by œstrogenic hormone, it is to be expected that this hormone will also influence the absorption capacity of the vagina. Baker[2] found in rats that the absorption of potassium ferrocyanide from the vagina changes during the course of the sexual cycle, being slowest in œstrus and most rapid in castrated animals, that is, the absorption varies directly with the thickness and the cornification of the vaginal squamous epithelium. The following investigation was carried out in order to elucidate the influence of œstrogens on the vaginal absorption in animals with no impeding epithelium (that is, with a columnar vaginal epithelium).

Through a soft rubber catheter, 0·5–1·0 mc. phosphorus-32 in the form of disodium hydrogen phosphate was injected into the vagina of an anæsthetized rabbit. The isotope was diluted with normal saline to 2 ml.; 1·0 mc. corresponded to 100 μgm. phosphorus. After withdrawal of the catheter, the vaginal opening was carefully closed by a soft clip. Immediately before the injection, the urinary bladder was emptied by pressing on the abdomen, and the vagina was repeatedly washed with normal saline. At various intervals (5, 10, 20, 30, 40, 70 and 120 min.) after the injection of phosphorus-32, about 1 ml. blood was removed from the ear vein and immediately centrifuged. Of the plasma, 0·1 ml. was pipetted on to an aluminium plate and the radioactivity determined by means of a Geiger–Müller tube and an electron counter. The absorption curves thus obtained were adjusted to equal height.

Thirty-six rabbits were used, eighteen of which were castrated and untreated, four were castrated and subcutaneously injected with about 5,000 I.U. œstrone in water solution ('Menformon' Pharmacia) daily for a week, four were castrated and intravenously injected with a single dose of œstrone (5,000 I.U. of the same hormonal preparation) one hour before the phosphorus-32 injection, and ten animals were normal controls (that is, not castrated). Ovariectomy was performed one to two weeks before the experiments. The curves in Fig. 1 show the mean values for the different observations in the four groups.

Fig. 1. Per cent radioactivity in the blood at various times after vaginal application of phosphorus-32. Curve 1, castrated, non-treated rabbits; curve 2, normal rabbits; curve 3, castrated rabbits, injected intravenously with œstrogen one hour before the vaginal application of phosphorus-32; curve 4, castrated rabbits, injected subcutaneously with œstrogen daily for a week before the vaginal application of phosphorus-32

The castrated, untreated animals (curve 1) have a slow vaginal absorption with maximum activity in the blood about 70 min. after the injection of phosphorus-32. Normal rabbits (curve 2) have a somewhat more rapid absorption, with maximum activity after about 40 min. The œstrone-treated animals (curves 3 and 4) show the most rapid absorption, with maximum activity only about 10–20 min. after injection of phosphorus-32.

One hour after stimulation by œstrogen, the vaginal absorption was thus considerably increased. This rapid action of œstrogen on the vaginal absorption is in full agreement with other rapid œstrogenic effects on the vagina, for example, vasodilatation[3] and permeability of the cell membrane to phosphate[4].

The increase in the rate of vaginal absorption after hormonal stimulation may well be due to more than one reason: (1) the above-mentioned vasodilatation; (2) the increased penetration of phosphate through the cell membrane; and (3) possibly also an increase of the absorption surface, that is, a dilatation of the vagina. From the experiments it is impossible to know how the increase in phosphate absorption is brought about. But it seems probable that the hormonal effect on the cell membrane plays an important part. (In several other experiments, œstrogen was given intravenously at various times after the injection of phosphorus-32 in order to investigate whether a rapid increase of absorption could influence the slope of the activity curve. However, no conclusions could be drawn on this point.)

The similarity of the absorption curves for the groups treated one hour and one week before application of phosphorus-32 is surprising. The effect of œstrogen on the factors which regulate absorption (vasodilatation, phosphate penetration, etc.) can scarcely reach a maximum within one hour after hormonal stimulation. Possibly the increasing œdema and the production of mucus in the cells of the vaginal mucous membrane again decrease the absorption. This would be parallel to the observation in rats by Baker mentioned earlier[2]: the increasing cornification of the vaginal epithelium during œstrus diminishes the absorption.

It is curious that the activity in the blood in untreated normal and untreated castrated animals is practically unchanged from 40 to 120 min. after

the injection of phosphorus-32. The vaginal route of application of radiophosphorus in rabbits therefore represents a means of getting a stable activity in the blood; the slopes of the individual curve are, however, so variable that the method is somewhat uncertain.

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Marine Invertebrate Preparations useful in the Bioassay of Acetylcholine and 5-Hydroxytryptamine

CERTAIN isolated muscle and heart preparations of marine invertebrates are highly sensitive to acetylcholine, to 5-hydroxytryptamine (enteramine, serotonin), or to both of these substances. Bacq[1] was the first and Ambache and Sawaya[2] among the more recent to demonstrate the sensitivity to acetylcholine of muscle strips from holothurians (Echinodermata). Inhibition of heart-beat of the bivalve mollusc, *Venus mercenaria*, was first used by Welsh[3] for the quantitative estimation of acetylcholine in tissue extracts. Recently, the same heart has been found to respond by increases in amplitude and frequency to low concentrations of 5-hydroxytryptamine[4]. Earlier, it had been reported[5,6] that certain molluscan hearts had a low threshold to 5-hydroxytryptamine or tissue extracts containing this substance. At the Marine Biological Laboratory, during the summer of 1953, the need arose for the quantitative estimation of acetylcholine and 5-hydroxytryptamine in certain tissues. Several species of echinoderms and molluscs from the Plymouth region were secured, and isolated muscle and heart preparations were screened for their suitability in bioassay of these substances. Available holothurians were *Holothuria nigra*, *Cucumaria normani*, *C. elongata*, and a single specimen of *Thyone* sp. Pieces or entire lengths of the longitudinal muscle bands were dissected free from the inner body wall and set up in the manner commonly used for muscle strips during recording of contractions. In the case of *C. normani* the peristomal (pharyngeal) retractor muscles were also tried. While all these preparations contracted in low concentrations of acetylcholine, especially after eserinization, the difficulties that were encountered by earlier workers[1,7] who had used other species of holothurians were obvious. Chief among these were spontaneous contractions, tendency to contract and remain contracted after eserine, and sensitivity to mechanical stimulation after eserine. This last was especially marked in the muscles from the single specimen of *Thyone* which, otherwise, were most promising since they were not spontaneously active.

Of these holothurians from the Plymouth region, *H. nigra* was considered most suitable. Its longitudinal body-wall muscles responded to as little as 5×10^{-9} gm./ml. acetylcholine chloride before eserine and often were not spontaneously active. The response to acetylcholine was nearly maximal at 10^{-7} gm./ml. Although a low concentration of eserine (10^{-6} gm./ml.) produced or increased spontaneous activity, it lowered the threshold to acetylcholine about a hundred-fold. When an acetylcholine contraction was superimposed on minimal spontaneous activity, a satisfactory quantitative measure of action was obtained. Isolated muscles of *H. nigra* were kept for twenty-four hours in aerated sea-water and there was little or no change in sensitivity to acetylcholine. The responses of holothurian muscle to 5-hydroxytryptamine were not observed.

Hearts from *Pecten maximus*, *Modiolus modiolus*, *Cyprina islandica* and *Buccinum undatum* were tested for their sensitivity to acetylcholine and 5-hydroxytryptamine. The heart of *Pecten* was cannulated and perfused *in situ* and also isolated and perfused. Much difficulty was encountered in maintaining a heart with a regular beat for an adequate period of time, and the sensitivity to acetylcholine and 5-hydroxytryptamine was low. The hearts of *Modiolus* and *Cyprina* were isolated and suspended in a bath, without cannulation, after the method employed with the heart of *Venus mercenaria*[8]. The *Modiolus* heart had a regular beat that held for many hours, but it was extremely insensitive both to acetylcholine and 5-hydroxytryptamine. In one instance no inhibition with acetylcholine was obtained at a concentration of 10^{-6} gm./ml. and no measurable excitation with 5-hydroxytryptamine at 10^{-7} gm./ml. Higher concentrations were not tested.

Three different hearts of *Cyprina* were tested. All beat at a slow rate but with a regular rhythm. The threshold dose of acetylcholine was about 5×10^{-10} gm./ml. With increasing doses the heart-rate was slowed in a graded manner; but there was no graded decrease in amplitude. At about 10^{-8} gm./ml. the heart stopped beating. The beat was quickly restored on washing. Eserine failed to potentiate the action of acetylcholine significantly. The *Cyprina* heart responded to 5-hydroxytryptamine with an increase in amplitude and frequency. Threshold was near 10^{-10} gm./ml. and a graded action was obtained up to 10^{-6} gm./ml.

On the *Venus* heart 'Mytolon' (supplied through kindness of Sterling–Winthrop Research Institute) is the most effective known acetylcholine antagonist[9,10]. Likewise, lysergic acid diethamide (*LSD*-25) (supplied through kindness of Sandoz Products, Ltd.) is the most effective antagonist for 5-hydroxytryptamine yet found for the *Venus* heart[11]. 'Mytolon' was found to be a highly effective antagonist for acetylcholine and *LSD*-25 for 5-hydroxytryptamine on the heart of *Cyprina*.

Considering relative abundance, hardiness of the animals and regularity and responsiveness of the heart to the substances to be assayed, the whelk, *Buccinum*, proved most satisfactory. Hence it was used in the identification and estimation of acetylcholine and an excitor substance, probably 5-hydroxytryptamine, in molluscan tissues. A detailed account of the results will appear elsewhere. The *Buccinum* heart was removed and a cannula inserted into the ventricle, usually by way of the auricle, but sometimes by way of the aorta if the auricle was accidentally torn from the ventricle. The attachment of the thin-walled auricle to the thick-walled ventricle is delicate, and two or three separate ligatures of rather coarse thread avoided the cutting and tearing that otherwise sometimes occurred. The *Buccinum* ventricle was perfused with sea-water, as were the other molluscan hearts and holothurian muscles. It was necessary to distend the ventricle with a small head of pressure to start it beating and to introduce drugs and extracts under the same pressure used in perfusing and washing.

The *Buccinum* ventricle had thresholds to acetylcholine and 5-hydroxytryptamine near those of *Cyprina*. The response to acetylcholine, however, is a decrease in amplitude with little change in frequency. The frequency increase produced by 5-hydroxytryptamine is often accompanied by an increase in tonus. 'Mytolon' blocked acetylcholine and *LSD*-25 blocked 5-hydroxytryptamine, as on the *Cyprina* heart. These highly effective antagonists were used in obtaining estimates of the amounts of acetylcholine and 5-hydroxytryptamine occurring together in a given tissue. Preliminary evidence that the heart of *Venus mercenaria* has an excitor innervation mediated by 5-hydroxytryptamine was recently presented[4]. Nerve ganglia and certain other tissues of molluscs from the Plymouth region were found to contain mixtures of heart-exciting and -inhibiting substances. Reliable quantitative estimates could be made only when the test heart was treated with 'Mytolon' or with *LSD*-25 to block one or the other substance. Since leaving Plymouth, we have found by chromatography and biological tests that ganglia of *Venus mercenaria* and the whelk, *Busycon canaliculatum*, contain 5-hydroxytryptamine and acetylcholine. It is likely that these were the substances present in the tissues studied at Plymouth.

Other large molluscs were not available at Plymouth; but Prof. Brodie Hughes, at the University of Birmingham, has kindly permitted me to say that he has tested the sensitivity of the isolated heart of *Mya arenaria* to acetylcholine and has used it in the bioassay of acetylcholine in cerebrospinal fluid. A record sent me by Prof. Hughes was made in February. The record shows a decrease in amplitude of about 30 per cent when 0·005 μgm./ml. acetylcholine was present in the bath. The decrease in amplitude with 0·006 μgm./ml. was nearly 50 per cent and with 0·01 μgm./ml. the amplitude was reduced to zero. Prof. Hughes has noted that *Mya* hearts become much more sensitive from the months of April to June. A similar seasonal shift in responsiveness of the *Venus* heart to acetylcholine was first noted by Prosser[12], who found them most sensitive in late winter and spring. Whether this is generally true of marine molluscs from northern waters is not known.

It is apparent from this brief survey that there are several species of marine molluscs in British waters the hearts of which may be useful in the determination and estimation of small amounts of acetylcholine and 5-hydroxytryptamine. It is also clear that there are holothurian species the muscles of which respond to low concentrations of acetylcholine.[4,11]

I am indebted to the Director and staff of the Laboratory, Citadel Hill, Plymouth, for the facilities that were provided for this work.

John H. Welsh

Biological Laboratories,
Harvard University,
Cambridge, Massachusetts. Feb. 11.

[1] Bacq, Z. M., *Arch. Int. Physiol.*, **49**, 20 (1939).
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[10] Welsh, J. H., and Taub, Rae, *Brit. J. Pharmacol.*, **8**, 327 (1953).
[11] Welsh, J. H. (unpublished).
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Life-history of the Rat Lung-worm and its Migration through the Brain of its Host

The metastrongylid lung-worm, *Angiostrongylus cantonensis* (Chen), was described from rats at Canton[1], reported by Yokogawa from Formosa[2], and has been found in about 5 per cent of wild brown rats, *Rattus norvegicus* (Erxl.), in Brisbane. It is now being maintained as a laboratory infection in white rats. The life-history shows some remarkable features.

The adult worms live in the pulmonary arteries. The unsegmented ova are discharged into the bloodstream and lodge as emboli in the pulmonary capillaries. They develop there into first-stage larvæ, which penetrate the alveoli, and presumably pass up the trachea and are swallowed, for they can be found in the intestinal contents and eventually pass out of the host in the fæces.

Garden slugs, *Limax* spp., act as intermediate hosts, a small, black, still unidentified, species being the best. The first-stage larvæ usually penetrate the foot of the slug; but developing larvæ may also be found in other parts of the body-wall and in between the internal organs. The first moult occurs in about twelve days and the second about five days later, at temperatures ranging from 70° to 79° F.

The third-stage larva remains quiescent within its two cast skins until ingested by a rat, when it is

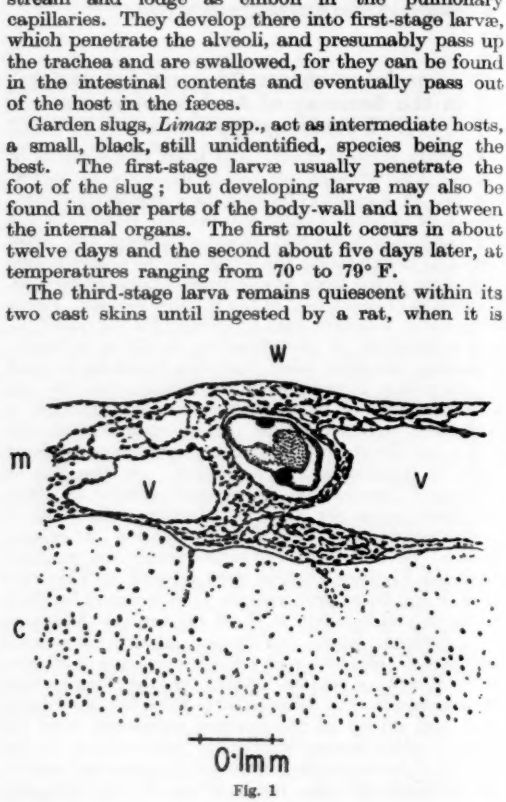

Fig. 1

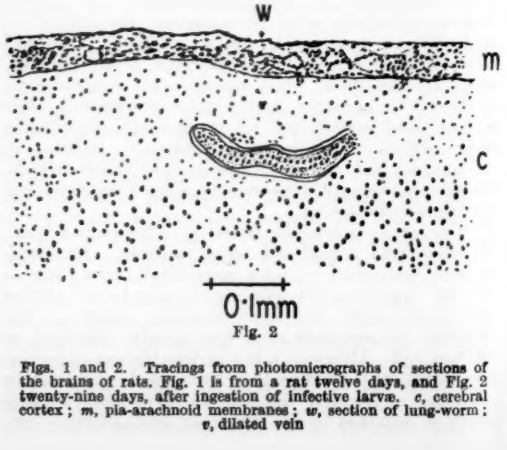

Fig. 2

Figs. 1 and 2. Tracings from photomicrographs of sections of the brains of rats. Fig. 1 is from a rat twelve days, and Fig. 2 twenty-nine days, after ingestion of infective larvæ. *c*, cerebral cortex; *m*, pia-arachnoid membranes; *w*, section of lung-worm; *v*, dilated vein

set free in the stomach and moves actively down the intestine. Larvæ have been found in the lower part of the ileum less than three hours after ingestion, and have been detected in the mesentery attached to it at this time. One was seen inside a small mesenteric vein, and it is presumed that they enter the blood-stream here.

Two days after ingestion, larvæ may be found in the grey matter of the cerebral hemispheres, particularly near the anterior pole, moving about in the cerebral tissue without causing any apparent damage (Fig. 1). They grow, and about the twelfth day the final moult occurs. The immature adults then emerge on the surface of the cerebrum, where they move about freely in the sub-arachnoid space and grow rapidly. The vessels of the pia-arachnoid become greatly dilated, and there is considerable cellular infiltration (Fig. 2).

On the twenty-ninth day after ingestion, the young adults begin their journey to the lungs. They have been recovered from the external jugular vein, left superior vena cava and right ventricle between the twenty-ninth and thirty-first days. By the thirty-second day, migration is usually complete, and all worms are found in the pulmonary arteries. Egg-laying begins a few days later, and first-stage larvæ appear in the fæces of the host between the fortieth and forty-fifth days.

The rats show no noticeable ill-effects from the quite gross lesions produced in the meninges and lungs.

This appears to be the first record of a parasitic nematode requiring a prolonged sojourn in the brain of its final host, before migrating to its definitive site at a relatively advanced stage of development. A detailed account of the work will be published elsewhere.

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[1] Chen, H. T., *Ann. Parasitol.*, **13**, 312 (1935).
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Allometric Growth in the Nematoda

Allometric growth has been studied, and shown to occur, in a large number of different animals; but the Nematoda do not appear to have been studied in this way. This is especially surprising in view of the simple shape of the parasitic members of this group and the extent to which the systematics of the group are dependent upon simple measurements of the individuals and of their constituent parts and, to a lesser degree, upon the ratios of these parts. In such cases allometric growth must be considered before too much stress is laid upon differences in ratios.

Data on the dimensions of the nematode species *Toxascaris leonina* (von Linst., 1902) have been gathered during a study of host specificity and variation within this species, and have been utilized to determine whether or not allometric growth occurs in the following cases: head and body width; growth in length of the œsophagus, the tail and the cervical alæ in relation to the body-length. The results show that allometric growth occurs in this species in all the relationships considered except, possibly, in the cases of body-breadth and total body-length, and œsophageal breadth and œsophageal length.

In the equation for allometric growth, $y = bx^k$, the value of b is of no biological significance since it simply gives the length of y when $x = 1$ and its value is dependent upon the units used in its calculation. k, however, is of value since it indicates the differences between the rates of growth of the two parts under consideration. In Table 1 the values of k obtained for the different growth-rates compared are given.

Table 1

Relationship considered		Allometric constant
y	x	k
Œsophageal length	: Body length	0·36
Cervical alæ length	: Body length	0·41
Tail length, ♀	: Body length	0·76
Tail length, ♂	: Body length	0·59
Diameter of the head	: Body length (whole)	0·46

These values of k indicate that the simple ratios of these dimensions must vary considerably in individuals of different total body-length and that such simple ratios must be treated, in systematics, with a certain amount of reserve.

The results obtained from a study of the relationships between the total body-length and body-breadth and œsophageal length and œsophageal breadth suggest that these relationships are isometric. These conclusions must, however, be treated with caution as the width of the individuals is the dimension most affected by preservation.

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March 12.

Liberation of Boron from 'Pyrex' and 'Hysil' Glass in Relation to Plant Growth in Water Culture

It is well known that plants in water culture may absorb appreciable quantities of boron from glassware such as 'Pyrex' and 'Hysil', which contain borosilicates. The literature has been reviewed by Hewitt[1] in relation to water culture techniques. The possibility of contamination resulting from the use of this type of laboratory glassware in *preparing* culture solutions has not, however, been generally recognized.

Using the method described by Hatcher and Wilcox[2], it was found that the boron content of copper-distilled water which had been boiled for one hour in a 'Pyrex' flask was 0·074 p.p.m. A comparable value was found for 'Hysil' flasks, namely, 0·070 p.p.m. boron. No boron could be detected in the original distilled water.

The response of flax seedlings to water which had been boiled for one hour in a 'Hysil' flask was examined as follows: the plants were grown in 1 lb. jam jars (soda glass) containing 300 ml. of a boron-free nutrient solution. 'Hysil'-boiled water was supplied in varying amounts up to 7·33 per cent by volume of the nutrient solution, which was renewed weekly, but not aerated. Ten seedlings were grown in each jar and after three weeks growth under glass in July the dry weights of shoots and roots were determined.

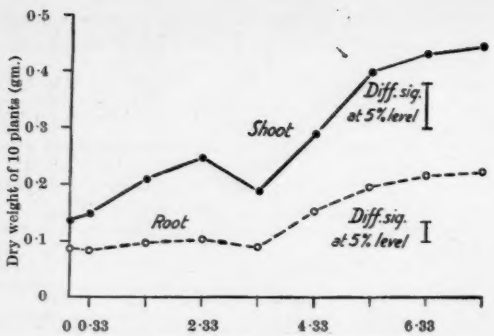

Fig. 1

The results are summarized in Fig. 1. It will be noted that where the proportion of 'Hysil'-boiled water exceeded 4·33 per cent of the total volume of nutrient solution, significant increases in the dry weights of both shoot and root resulted. The concentration of boron at this dilution of the 'Hysil'-boiled water was only 0·0030 p.p.m.

These findings arose from attempts made in this department to verify the claim of Eaton[3] that β-indolyl acetic acid may, to some extent, replace boron as an essential element in plant growth. When aqueous solutions of this acid prepared in 'Hysil' vessels were added to boron-deficient nutrient solutions significant increases in the growth of flax were frequently obtained. This result can now be attributed, at least in part, to the boron liberated from the glassware.

In recent years much attention has been centred on the testing of a wide range of organic compounds for biological activity. It is now evident that where the level of boron is sub-optimal for the growth of the plant or plant organ, or is quite unknown, precautions should be observed to ensure that, in the preparations of solutions for test, no contamination with borosilicate glassware has occurred.

We are indebted to Dr. T. H. Rose and Mr. T. Williams, of the National Agricultural Advisory Service, Wye, for the boron estimations.

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J. Dilnot

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Feb. 6.

[1] Hewitt, E. J., Tech. Comm. 22, Commonw. Bur. Hort. Crops (1952).
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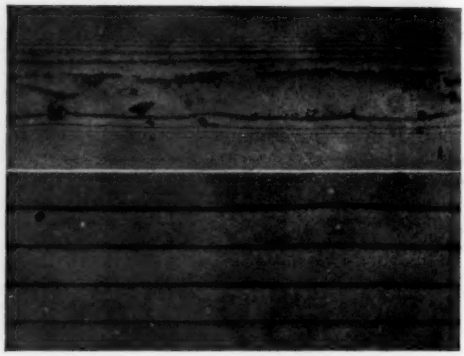
Sharpening the Microtome Knife

Several articles have been written on the most suitable method of sharpening the knife of a microtome. The usual manner of sharpening is grinding, honing, polishing and stropping, and there are several different methods for each of those operations. There is obviously a lack of a quantitative measuring method by means of which the result of different sharpening methods can be tested. The only fairly reliable method still used is the one indicated by von Mohl[1].

The edge of the microtome knife is formed by the line of intersection of the facet surfaces. Decisive for the quality of the knife are evenness and surface finish. Therefore, a good sharpening method must result in both these qualities for the facet surfaces. Just as important is a measuring method which gives an absolute measurement of the sharpening result.

A machining method which satisfies the highest demands of evenness and surface finish of steel is lapping against cast-iron. This method is, as a rule, used by the measurement workshops in factories where precision goods are manufactured. It has proved extremely advantageous for the purpose of sharpening microtome knives. Owing to its speed with regard to removing the material and its performance with regard to the evenness and surface finish, it alone can replace grinding, honing, polishing and stropping.



By means of multiple interference microscopy, according to Ingelstam[2], it is possible to check the machined facet surfaces quantitatively. By using this method, deficiencies in evenness and surface finish can be measured to an accuracy of about 50 A. The result of different sharpening procedures can thus be given in absolute measurement. The facet surface of a microtome knife direct from the factory (Fig. 1), and a lapped knife (Fig. 2), are shown on the accompanying interferograms (× 600). The interference fringes give a direct profile curve of the facet surface. The new knife shows signs of machining at a depth of 2000 A., that is, rather a good surface finish but, on the other hand, variations in evenness of about 3000 A. longitudinally and finally a considerable curving of the facet surface, which means that the clearance angle of the knife can never be adjusted against the block of tissue. The figures corresponding to the lapped surface are 50–200 and 500 A. respectively.

A more detailed report of this method will be published later.

I am indebted to Mr. Erik Gisslén, chief engineer, and the SKF Factory, Göteborg, for their kind assistance and for the facilities placed at my disposal which made it possible to carry out this investigation. The cost of the investigation was defrayed by grant from the Swedish Medical Science Research Council.

O. Hallén

Department of Histology,
Faculty of Medicine,
Göteborg C. Jan. 30.

[1] Mohl, H. v., *Bot. Z.*, **15**, 249 (1857).
[2] Ingelstam, E., Reports from the Laboratory of Optics, Royal Inst. of Technology, Stockholm, Sweden, No. 14 (1951).

FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, May 17

BRITISH SOCIETY FOR THE HISTORY OF SCIENCE, PHILOSOPHY OF SCIENCE GROUP (in the Joint Staff Common Room, University College, Gower Street, London, W.C.1), at 5.30 p.m.—Prof. Willard V. Quine: "The Nature of Mathematical Truth".

UNIVERSITY OF LONDON (at Guy's Hospital Medical School, St. Thomas Street, London, S.E.1), at 5.30 p.m.—Dr. B. Brodie (U.S.A.): "Biochemical and Clinical Implications of Studies in Drug Metabolism". (Further Lecture on May 19.)*

UNIVERSITY OF LONDON (at Queen Mary College, Mile End Road, London, E.1), at 5.30 p.m.—Prof. Werner Fenchel: "Duality in the Theory of Convex Functions". (Further Lecture on May 18 at above address, and on May 21 at University of London, Senate House, London, W.C.1.)*

ROYAL SOCIETY OF ARTS (at John Adam Street, Adelphi, London, W.C.2), at 6 p.m.—Dr. Henry Phillips: "The Chemistry of Leather". (Cantor Lecture.) (Further Lectures on May 24 and 31.)

Monday, May 17—Thursday, May 20

ELECTRICAL ASSOCIATION FOR WOMEN (at the Town Hall, Torquay)—Twenty-ninth Annual Conference: "Electricity and the Countryside".

Monday, May 17—Friday, May 21

ROYAL SCOTTISH FORESTRY SOCIETY (headquarters at Pitlochry)—Centenary Excursion.

Tuesday, May 18

ROYAL SOCIETY OF ARTS, COMMONWEALTH SECTION (at John Adam Street, Adelphi, London, W.C.2), at 5.15 p.m.—Sir William Halcrow: "Engineering Developments in Central Africa".

SOCIETY OF CHEMICAL INDUSTRY, AGRICULTURE GROUP (at the Chemical Society, Burlington House, Piccadilly, London, W.1), at 5.30 p.m.—Annual General Meeting. Mr. W. Leonard Hill: "Making Known" (Chairman's Address).

UNIVERSITY OF LONDON (at the Institute of Archæology, Inner Circle, Regent's Park, London, N.W.1), at 5.15 p.m.—Mr. A. Digby: "Recent Work in Archæology outside Europe", (2) "Central America".*

Tuesday, May 18—Friday, May 21

ILLUMINATING ENGINEERING SOCIETY (at Southport)—Summer Meeting.

Wednesday, May 19

PHYSICAL SOCIETY and the INSTITUTE OF PHYSICS (in the Physics Lecture Theatre, University College, Gower Street, London, W.C.1), at 4.15 p.m.—Joint meeting on "Electron Physics".

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, London, S.W.7), at 5 p.m.—Scientific Papers.

ROYAL SOCIETY OF MEDICINE, COMPARATIVE MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Annual General Meeting, followed by discussion on "Physiological and Pathological Aspects of Locomotion in Man and Animals".

SYSTEMATICS ASSOCIATION (at the Geological Society of London, Burlington House, Piccadilly, London, W.1), at 5 p.m.—Colloquium on "The Species Concept in Palæontology".

ROYAL STATISTICAL SOCIETY (at the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1), at 5.15 p.m.—Mr. J. Durbin and Mr. A. Stuart: "Non-Response and Clustering in Sample Surveys: an Experimental Study".

Thursday, May 20

ROYAL AERONAUTICAL SOCIETY (at the Royal Institution, Albemarle Street, London, W.1), at 6 p.m.—Dr. A. E. Russell: "The Choice of Power Units for Civil Aeroplanes" (42nd Wilbur Wright Memorial Lecture).

Friday, May 21

INSTITUTE OF NAVIGATION (at the Royal Geographical Society, 1 Kensington Gore, London, S.W.7), at 5 p.m.—Dr. E. S. Calvert: "Visual Aids to Bad-Weather Approach".

ROYAL INSTITUTION (at 21 Albemarle Street, London, W.1), at 9 p.m.—Prof. A. C. B. Lovell: "Britain's Giant Radio Telescope".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

SENIOR SCIENTIFIC OFFICER (with a university degree of high standard or equivalent qualifications in appropriate field, and with several years relevant research experience) in the Department of Supply, Defence Standards Laboratories, Maribyrnong, Victoria, Australia, for research into the development and application of techniques of optical instrument technology, photometry and colorimetry—The Senior Representative (A.P.13), Department of Supply, Australia House, The Strand, London, W.C.2 (May 20).

ASSISTANT LECTURER, LECTURER OR SENIOR LECTURER IN ORGANIC CHEMISTRY at the University College of Khartoum—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (May 21).

HEAD (with a higher degree, recent experience in research, teaching experience in a university or technical college, and/or industrial experience) OF THE DEPARTMENT OF METALLURGY, County Technical College, Wednesbury—The Director of Education, Department F.E., County Education Office, Stafford (May 22).

TECHNICIAN (preferably with some experience in photography and/or microtechnique) IN THE DEPARTMENT OF BIOLOGY—The Registrar, University College of Swansea, Singleton Park, Swansea (May 22).

CHAIR OF APPLIED ELECTRICITY—The Secretary and Registrar, University College of North Wales, Bangor, N. Wales (May 24).

LECTURER (with special qualifications in palæontology) IN GEOLOGY—The Secretary, University of Durham, 38 North Bailey, Durham (May 24).

SENIOR AGRICULTURAL ECONOMIST and an AGRICULTURAL ECONOMIST (with a degree in economics or agriculture, and with research experience in economics or agricultural economics)—The Secretary, School of Agriculture, The University, Cambridge (May 25).

ASSISTANT LECTURER IN PURE MATHEMATICS and an ASSISTANT LECTURER IN GEOGRAPHY—The Registrar, King's College, Strand, London, W.C.2 (May 28).

ASSISTANT LECTURER, Grade III, or LECTURER, Grade II (preferably with a special knowledge in vertebrate palæontology or palæobotany) IN THE DEPARTMENT OF GEOLOGY—The Registrar and Secretary, The University, Bristol (May 29).

ASSISTANT LECTURER IN GEOLOGY—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (May 29).

SENIOR LECTURER IN SOCIAL STUDIES, a SENIOR LECTURER IN CHEMICAL ENGINEERING, a LECTURER IN MATHEMATICS, and a LECTURER IN TEXTILE SCIENCE—The Principal, Royal Technical College, Peel Park, Salford 5 (May 29).

ASSISTANT LECTURER OR LECTURER (with special qualifications in inorganic chemistry) IN THE DEPARTMENT OF CHEMISTRY—The Registrar, University College of Wales, Aberystwyth (May 30).

LECTURER IN GEOLOGY with special reference to Stratigraphy—The Secretary, Queen's University, Belfast (May 30).

ASSISTANT LECTURER (preferably with an interest in Western Europe and/or climatology) IN GEOGRAPHY—The Secretary, University College London, Gower Street, London, W.C.1 (May 31).

LECTURER (graduate in agriculture and specialized in poultry) IN POULTRY, at Gwebi Agricultural College, Southern Rhodesia—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (May 31).

LECTURER (with university teaching qualifications and experience) IN STATISTICS OR STATISTICAL MATHEMATICS, at the University, Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (Hong Kong, May 31).

MILES AMES FELLOW (with Ph.D. degree or its equivalent in chemistry or biochemistry) IN ENDOCRINOLOGY, in the Department of Chemical Pathology, to carry out original work on steroid hormones—The Secretary, King's College Hospital Medical School, Denmark Hill, London, S.E.5 (May 31).

PLANT BREEDER (science graduate with aptitude for research, and preferably with postgraduate training and experience in plant breeding, statistics, field experimentation and soil science) IN THE FIELD HUSBANDRY BRANCH, Department of Research and Specialist Services, Southern Rhodesia Government—The Secretary, Rhodesia House, 429 Strand, London, W.C.2 (May 31).

ASSISTANTS IN THEORETICAL OR EXPERIMENTAL PHYSICS in the Department of Natural Philosophy—The Secretary, The University, Aberdeen (June 1).

DEMONSTRATOR (with a good honours degree in physiology, biochemistry or chemistry with subsidiary physiology) IN CHEMICAL PHYSIOLOGY—The Registrar, The University, Manchester (June 1).

RESEARCH ASSISTANT IN MATHEMATICAL STATISTICS and a RESEARCH ASSISTANT IN NUMERICAL ANALYSIS in the Department of Applied Mathematics—The Registrar, The University, Liverpool (June 1).

CHIEF OF RESEARCH AND DEVELOPMENT, LEADER OF CHEMISTRY SECTION, LEADER OF METALLURGY SECTION, LEADER OF ENGINEERING AND CHEMICAL ENGINEERING SECTIONS, and a SENIOR MATHEMATICAL PHYSICIST, with the Australian Atomic Energy Commission, Sydney—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2 (Sydney, June 5).

LECTURER (with a good honours degree and practical experience, and preferably with research experience) IN CIVIL ENGINEERING—The Registrar, The University, Nottingham (June 5).

LECTURERS (2) IN GEOLOGY (General and Economic)—The Secretary, The University, Edinburgh (June 5).

ASSISTANT LECTURER IN CHEMISTRY at the University College of the West Indies—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 8).

ASSISTANT AGRICULTURAL ECONOMIST (graduate in economics and/or agriculture)—The Registrar, The University, Bristol 8 (June 12).

LECTURER IN THE DEPARTMENT OF BIOCHEMISTRY—The Secretary, The University, Edinburgh (June 15).

RESEARCH FELLOW (with an honours degree in chemistry or agricultural chemistry, and experience in the chemistry of soils) IN SOIL CHEMISTRY, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 20).

LECTURER IN CROP PRODUCTION (Plant Breeding), a LECTURER IN ANIMAL PRODUCTION, a LECTURER IN ANIMAL HEALTH, and a LECTURER IN AGRICULTURAL ENGINEERING, at the University College of the Gold Coast—The Secretary, Inter-University Council for Higher Education in the Colonies, 1 Gordon Square, London, W.C.1 (June 30).

RESEARCH STUDENTS (with the degree of Bachelor or Master of a British University, other than Manchester) IN SCIENCE—The Registrar, The University, Manchester (July 1).

SENIOR LECTURER IN METALLURGY at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (New Zealand, July 1).

SENIOR LECTURER IN PHYSICS at Rhodes University, Grahamstown, South Africa—The Secretary, Association of Universities of the British Commonwealth, 5 Gordon Square, London, W.C.1 (South Africa, July 1).

ASSISTANT LECTURER, Grade B, IN THE DEPARTMENT OF CHEMISTRY, College of Technology and Commerce, Cardiff—The Director of Education, City Hall, Cardiff.

ASSISTANT (medically qualified, and preferably with experience in bacteriology) IN THE BACTERIOLOGY DEPARTMENT—The Secretary, University College Hospital Medical School, University Street, London, W.C.1.

ENGINEER (Basic grade) to assist in the design and development of mechanical equipment, such as laboratory instruments and light and medium mechanical engineering devices and prototypes to scientists' and Service requirements—The Administrative Officer (Recruitment), Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 58/W.G.E./2.

ENGINEER (with first- or second-class honours degree or equivalent in mechanical or aeronautical engineering, and with practical experience), at the Royal Aircraft Establishment, Farnborough, Hants, for work in the Armament Division on research and development of air armaments and their installation in aircraft—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting C.303/54A.

LECTURER IN MATHEMATICS and a LECTURER IN PHYSICS at the Higher Teachers' Training College, Baghdad—The Cultural Attaché, Iraqi Embassy, 22 Queen's Gate, London, S.W.7.

LECTURER (with previous university teaching experience, and preferably with an interest in physiology and ecology) IN BOTANY—The Principal, Sir John Cass College, Jewry Street, London, E.C.3.

PHYSICIST (with first- or second-class honours degree in physics, and a bias towards physical chemistry and physics of solids) at the Royal Aircraft Establishment, Farnborough, to work with the Electrical Engineering Department on investigations concerning physics of solids, particularly with regard to formation of oxide and graphite films on metals by rubbing action of graphite brushes, and study of factors influencing oxidation of petrol and oils, and consequent fire risk with electrical equipment so contaminated—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting A.119/54A.

PLANT PATHOLOGIST or PLANT PHYSIOLOGIST (with a degree in natural science and training in plant pathology or plant physiology, and preferably with experience in coffee diseases) in Kenya, to investigate diseases of coffee, at the Coffee Research Station, Ruiru—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/7/015.

RESEARCH ASSISTANT (honours graduate, with zoology or physiology as principal subject, and preferably with a knowledge of physics and/or postgraduate laboratory experience) IN THE RADIOBIOLOGY LABORATORIES—The Administrative Officer, Christie Hospital and Holt Radium Institute, Manchester 20.

SENIOR EXPERIMENTAL OFFICER (with H.S.C. (science) or equivalent qualification) to act as Chief Programmer for an electronic digital computer, and to advise on the best methods of proposing problems for the machine—The Administrative Officer (Recruitment), Atomic Weapons Research Establishment, Aldermaston, Berkshire, quoting 133/W.G.E./2.

SENIOR LECTURER IN PHARMACOLOGY and a SENIOR LECTURER IN PHARMACEUTICS—The Registrar, College of Technology and Commerce, The Newarke, Leicester.

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